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BULLETIN OF THE

TAYLOR SOCIETY

AN INTERNATIONAL SOCIETY TO PROMOTE THE SCIENCE
AND THE ART OF ADMINISTRATION AND OF MANAGEMENT

TIME STUDY

Proceedings of the Spring Meeting
Detroit, May 7 and 8, 1928

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2. To secure the gradual elimination of unnecessary effort and of unduly burdensome toil in the accomplishment of the work of the world.

3. To promote the scientific study and teaching of the principles governing organized effort, and of the mechanisms of their adaptation and application under varying and changing conditions.

4. To promote general recognition of the fact that the evaluation and application of these principles and mechanisms are the mutual concern of the community, the worker, the manager and the employer.

5. To inspire in labor, manager and employer a constant adherence to the highest ethical conception of their individual and collective responsibility.

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VOL. XIII JUNE, 1928 No. 3

Contents

Comment 105

TIME STUDY

The Taylor Technique of Time Study . . 106
By Dwight V. Merrick
Discussion by L. K. Fyler

Study of Fundamental Operations of a Machine vs. Study of Individual Operations 112
By G. E. Schulz

Unit Times vs. Overall Times 117
By Earl E. Watson

Classification, Filing and Use of Time Study Data 118
By Stewart M. Lowry
Discussion by Eugene Bouton and Allan H. Mogensen

The Relations of Time and Motion Study . 126
By Lillian M. Gilbreth

Standardization of Conditions and Analysis of Operations 128
By G. J. Stegemerten
Discussion by Howard G. Benedict and Elliott Dunlap Smith

Selection of Workers for Observation . . . 136
By Joseph A. Piacitelli

Number of Workers to be Observed . . 138
By Stephen B. Sponder

Methods of Observation 141
By A. L. Kress
Discussion by Hugo Diemer

Analysis of Data and Computation of Net Times 146
By George De Graw

Computation of Allowances 148
By Neele E. Stearns

The Production Study as a Check 152
By L. W. Haskell
Discussion by Harry Ford

The Application of Time Study to Shop Operations 155
By L. W. Haskell

The Application of Time Study to Office Workers Both Clerical and Machine . . 157
By W. H. Leffingwell

Comment

THE PROCEEDINGS of the spring meeting held in Detroit were not recorded stenographically and a few discussors were not able to submit memoranda covering their contributions; otherwise this issue of the Bulletin constitutes a full report of the meeting.

FOR THE success of the meeting we are indebted to a Detroit executive committee consisting of George D. Babcock, Dodge Brothers, Inc.; L. W. Haskell, of the same firm; Harry Ford, Cadillac Motor Car Company, President of the Society of Time Study Engineers; Charles Mottashed, Hudson Motor Car Company, and W. W. Nichols, representing the Society of Industrial Engineers. Acknowledgment is also made to the Society of Time Study Engineers and the Society of Industrial Engineers for active co-operation, and to the latter for the loan of a time study exhibit.

IMPORTANCE of the subject is indicated by the fact that three conferences on time study were held in three industrial centers within a period of three months—two by the Society of Industrial Engineers in Chicago and Milwaukee and one by the Taylor Society in Detroit. The published proceedings of the meetings of S. I. E. are noticed on another page. There is indicated also the fact that the sponsor organizations are concerned over the average quality of time study practice which is developing in this period of rapid extension. For time study can be precise and extremely helpful in the establishment of dependable standards, or it can be loose and harmful. There is much that is competent, but we fear that there is considerable which is incompetent. There are too many instances of managements which decide to develop a time study department and then give the responsibility for so serious an undertaking to a $2500 man. The S. I. E. Proceedings and this issue of the Bulletin should be studied as companion documents; the former is a statement of principles and procedures agreed upon and formulated by a committee; this Bulletin is the record of a general discussion in which, following a statement of classic Taylor principles, individual points of view and experiences are recorded.

Time Study

The Proceedings of the Spring Meeting of the Taylor Society,
Detroit, May 7 and 8, 1928

The Taylor Technique of Time Study

By DWIGHT V. MERRICK
Consulting Engineer, New York

IT IS fitting that a meeting devoted to consideration of the present status of time study should be held in this city. It was here in 1895 at a meeting of the American Society of Mechanical Engineers that Frederick W. Taylor presented his first paper on time study and rate setting, "A Piece Rate System."

His audience was not at all prepared for his ideas and methods. Consequently the discussion of that paper ignored consideration of the new idea of determining the time allowance for work by means of time studies, which seemed impracticable to his audience, and centered on the differential piece rate system, which to Taylor was secondary and only illustrative of the possibilities of measurement of work. He tried to lead the discussion toward time study, but with little success. He decided to try again and eight years later presented a second paper, "Shop Management," in which was virtually an appeal to manufacturers to give time study the attention it merited. Since that time, and more particularly since the publicity given scientific management by the Eastern Rate Case hearings in 1910-11, the use of time study has spread rapidly and has become an essential function in well organized plants.

The idea of time study was not absolutely original with Taylor. Something over a hundred years ago the French engineer Perronet, and later the English economist Babbage, made time studies of the production of pins; but there is no evidence that these studies ever became widely known or influenced management. Taylor got the idea from watching one of his professors at Exeter time students working on mathematical problems.

Credit must be given to Taylor for demonstrating the practical use of time study, as a tool of management, and particularly for conceiving, first the measurement of work, and second the measurement of elementary times which can be used over and over again in building up times for variable operations. He early recognized that it would be more accurate to take each element of the various kinds of work with a stop watch and find the quickest time in which a job could be done by summing up the total time of its component operations, and adding a reasonable percentage of allowance, than by searching through records of previous performances.

At first many mistakes were made. For example, time studies were started without giving due consideration to standardization of methods and equipment, or to assurance of a steady flow of material to the worker. Also, it was at first thought by some that time studies should be taken without the knowledge of the worker. Stop watches were concealed, sometimes in cases made to look like a book, and sometimes in the observer's pocket. The time study man in these instances had to go behind some object of concealment in order to make a record of his observations. In another instance, the observer sat in a glass cage near the worker and telephoned his readings to the men in the office. These methods were soon discarded by reputable engineers, first, because they are underhanded, and second, because they are absolutely futile in view of the fact that they do not permit continuous runs or secure workers' co-operation. Without these, results are valueless.

Procedures

Much has been said and written on present methods of time study—equipment, workers to be selected, methods of making observations, various ways of computing times, allowances for fatigue and delays, and on incentive methods of wage payment based on standard times. Every technician[1] is more or less familiar with these variations in detail. It is hoped that profitable appraisal of these will be brought out in the discussions of this meeting.

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[1] For the author's methods consult his "Time Study for Rate Setting," The Engineering Magazine Company, New York, 1919.

However, whatever variations in detail may be found in the methods of individuals, there seems to be a basic procedure which should be observed. This basic procedure involves:

First: preparatory steps — (1) a careful survey of the operations and perfection of all influencing conditions; (2) analytical breaking down of the operation into its simple elements:

Second: time study itself—(1) observation and record of the times taken in performing each of the simple elements; (2) analytical study of the recorded times; (3) computation of allowances for fatigue and unavoidable delays; (4) determination of standard times, due and fair consideration being given to the character of the work and the demands upon the operator; (5) preparation from the analysis of an instruction sheet which shows the sequence of elementary motions, the standard time for each, the allowance for fatigue and delays, and the time in which the work should be performed.

Taylor included motion study, and other aspects to which special names have since been given, under the general term time study.

Too much emphasis cannot be placed upon the importance of taking elementary times, rather than of taking overall times—the times of complete jobs without detailing the motions. The method of taking elementary times is flexible and lends itself easily to standardization and classification, and to adjustments on instruction sheets under changing conditions. Such classified unit times permit comparisons of time studies of a job before and after a change in the details of operation, on different types of machines, such as single and multiple purpose. They lend themselves to at least predetermining prospective times where changes in processes or models are made periodically.

Uses of Time Study

Experience with time study has disclosed uses as a tool of management more numerous that was at first perceived. At first, and until recently, it was looked upon primarily as a means of increasing output per worker, with little thought of method. Now, as a result of experience, one is able to enumerate a long list of uses. The most important follow. Many of these will undoubtedly be elaborated upon in the subsequent discussion.

1. Determination of possible improvement in the equipment and in the surrounding conditions for performing a given operation.
2. Improvement in conditions extending as far as shop layout generally.
3. Improvement in methods of performing operations on the basis of improved equipment and conditions.
4. Establishment of a permanent record of best practices, in terms of units which may be combined to fit various circumstances.
5. Establishment of clear and understandable instructions for workers.
6. Increase of output per worker.
7. Reduction in unit costs.
8. Maintenance of quality at a predetermined standard. In competitive industries quality of product is now more important than it has been in the past. In such industries items usually have an established market price. If the standard of quality is not maintained there is danger of another factor contributing to sales resistance.
9. Establishment and maintenance of equitable rates of pay to workers.
10. Facilitation of the routine work of design in the engineering department, and of the estimation of the influence of design on cost and other factors.
11. Facilitation of the planning, scheduling and general control of operations. Standard times and capacities of machines and of operatives, supplemented by data relative to the degree to which particular operatives have acquired capacity to achieve standard performance, permit proper balance of equipment and of labor force, and proper flow of materials through the various processes.
12. Standardization of costs. Only to the degree to which there are standard conditions reflected in standard times of operation performance, can standard costs become efficient. Symbols for individual operations can be set up on instruction sheets and used in cost distributions. Then, by having the actual labor cost analysis and actual time of production parallel the incentive rate and the time of performance shown on the instruction sheet, a direct comparison can be made between actual and ideal conditions and costs.
13. Budgeting. The standard conditions and times

resulting from time study make possible modern perfection in budgeting. Material and labor requirements, and their costs and other expense, may be forecast with precision and minimum inventories may be maintained in terms of necessary output.

14. Facilitation of changes in design, equipment and processes. This is a very important contribution of time study—especially unit time study—in a dynamic industry such as that for which this city is famous. In an engineering department developments are continually appearing, such as change of style or model, which require alterations in methods and equipment. In order to determine the influence of such alterations on costs, the element of time in processing must be considered. It is obvious that a well developed time study department can supply the elementary time standards needed by the engineer and others in calculating the influence of proposed changes on costs to determine whether or not such changes will pay. And if the changes are decided upon, the time study data provide a basis for calculating the modifications of equipment, tools, methods and personnel essential to carrying out the new program.

Because the instruction sheet is a part of the manufacturing process any change in the process should require a revision of the elementary operations composing a piece of work or a complete operation. This is necessary because the instruction sheets are not only the record of the best practice but serve as a basis for the determination of the incentive rates. In the broad sense the operators are paid for each elementary operation performed. Therefore, if operation times affected by process changes are not revised, inequalities in earnings for equal efficiencies develop.

There are instances where the elimination or addition of an elementary operation may affect the times of other elementary operations. Often these component parts of time may consist of two motions done at the same time; for example, one thing done with one hand and another with the other. From a practical point of view, the time would have to be taken from the start of the motion of the first hand, until the completion of the motion of the other. In some instances it may be advisable to make a complete new study, setting up a new division of elementary motions, or only new elementary motions adjacent to the point of change.

This illustration serves to show the importance of the instruction sheet as an instrument of control and the importance of any change in process. The greatest care is necessary in order to maintain a balance in earnings and, as far as possible, eliminate the effect of the personal equation that enters into all considerations of time where it concerns human effort.

One company with which I am acquainted, in order to maintain a control by means of the instruction sheets and tie in the material specification with these instructions, has developed a simple and effective method of handling proposed changes in process under the caption, "Change in Process." A form is circulated describing the change, giving the reasons, and to what consideration has to be given such as:

Production material needed and cost
Disposition of present stock
Necessary equipment and cost
Time study
Expectation of breakdowns
Maintenance
Power needed
Accident hazard
Quality standard
Specifications, etc.

Before the proposed change becomes effective, the approvals of the following divisions are recorded:

Manager
Technical Manager
Divisional Superintendent
Stores
Employment Superintendent
Planning Superintendent
Time study, etc.

A change may originate with any of the above, or be objected to by any one of them.

In case of approval, and before any change is made in the standard time for performance of work and in the incentive rate, adequate measures are taken to acquaint the workers with the proposed change. Such a change may result in an increase or decrease in the time for the work, depending on whether elementary times are added or obsolete ones eliminated, and consequently necessitate an adjustment in the incentive rate. Changes of this character do not ultimately affect the operators' hourly earnings, but do temporarily break down the rhythm that has been acquired. Therefore, in justice to the worker, due notice should be given of any change, in order to overcome mental resistance when it is made effective.

Time Study and the Workers

Experience has taught us a fundamental principle of time study; namely, that material gain to the employer is substantial and lasting only when the employe enjoys a corresponding gain. The interest and responsibility for the development of time study must be shared between management and the workers. No time study should be made without clearly and completely explaining its objects, methods and benefits to all who are concerned. In this and other ways may be secured that confidence and co-operation without which good time study is impossible.

In this connection I should like again to refer to a point already made: that in a large sense, where instruction sheets with unit times prevail, operators are paid for elementary operations rather than for complete jobs. When workers come to appreciate this, many difficulties in rate reconstruction accompanying changes in design or process are obviated. Workers understand just at what point rate change is involved, and why. This helpful understanding can exist only where workers are taken into the complete confidence of the management with respect to time study.

Appendix

Frederick Winslow Taylor's most complete statement concerning time study is here reproduced by permission from Vol. 34 (1912), p. 1199, of the *Transactions of the American Society of Mechanical Engineers.*

Time study is the one element in scientific management beyond all others making possible the "transfer of skill from management to men." The nature of time study, however, is but imperfectly understood, and it is therefore important to define it clearly. "Time study" consists of two broad divisions, first, analytical work, and second, constructive work.

The analytical work of time study is as follows:

a. Divide the work of a man performing any job into simple elementary movements.

b. Pick out all useless movements and discard them.

c. Study, one after another, just how each of several skilled workmen makes each elementary movement, and with the aid of a stop watch select the quickest and best method of making each elementary movement known in the trade.

d. Describe, record and index each elementary movement, with its proper time, so that it can be quickly found.

e. Study and record the percentage which must be added to the actual working time of a good workman to cover unavoidable delays, interruptions, and minor accidents, etc.

f. Study and record the percentage which must be added to cover the newness of a good workman to a job, the first few times that he does it. (This percentage is quite large on jobs made up of a large number of different elements composing a long sequence infrequently repeated. This factor grows smaller, however, as the work consists of a smaller number of different elements in a sequence that is more frequently repeated.)

g. Study and record the percentage of time that must be allowed for rest, and the intervals at which the rest must be taken, in order to offset physical fatigue.

The constructive work of time study is as follows:

h. Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can be readily found.

i. From these several records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding proper percentage allowances, to find the proper time for doing almost any class of work.

j. The analysis of a piece of work into its elements almost always reveals the fact that many of the conditions surrounding and accompanying the work are defective; for instance, that improper tools are used, that the machines used in connection with it need perfecting, that the sanitary conditions are bad, etc. And knowledge so obtained leads frequently to constructive work of a high order, to the standardization of tools and conditions, to the invention of superior methods and machines.

It is unusual to make a study such as this of the elementary movements of the workmen in a trade. The instances in which this has been done are still rare. Most of the men who have made what they call "Time study" have been contented with getting the gross time of a whole cycle of operations necessary to do a particular piece of work, and at best they have thrown out the time when the workman was idle, or evidently purposely going slow.

Discussion

L. K. Fyler.[2] One of the first considerations for good observation, job analysis, recording, and computing of time studies is the employment of proper observers, of keen and analytical mind. Both men and women have been found satisfactory, the latter particularly for the observation of work on which they have had some experience as workers. All observers must realize the limitations of human nature in order to judge and record the proper element times.

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[2] Development Department, Eaton, Crane & Pike Company, Pittsfield, Mass.

The selection of proper observers is essential, particularly if the selected element times are to be indexed and placed on file for future use. Improperly established element times may cause many errors in future combinations of elements when new task times are being formulated from records.

The position of the observer with respect to the worker while under observation is important. The observer should not be close to or in front of the worker, thus distracting the latter's attention. He may be at either side or a little to the rear, always having the motions of the employe in full view. It is best not to interrupt the worker with questions or suggestions of change in method while the study of several cycles of work is being made. Notes and symbols can be made by the observer on the data sheet, recording abnormal conditions or increments of time. These can be discussed with the worker and others at a later period. By following this practice the observer will find that the best time studies are made by having the stop watch run continuously from the start to the finish of the study, with complete notes covering all delays.

Under no consideration should studies be made without first explaining to the worker what is to be done. In most cases it is decidedly advantageous to have previously acquainted the foreman or overseer with the plan which is to be pursued. Having informed the department head and worker, the observer will find that a brief study of the methods and motions, as performed when the time study analysis is started, will be of considerable value later for comparative purposes.

Any change in the equipment, methods or motions should be carefully explained to the worker and an opportunity afforded for him to become proficient in the new method before final observations are made. Proper instruction and training in changed methods are of vital importance.

Special attention should be paid by the observer to recording the description of motions and elements which are being studied. Experience has shown that it is possible to use abbreviations to such an extent in describing an element that it is difficult for other observers to interpret, check or use the element times at some later date. It is well to record on the detail study or data sheets a complete description of the motion of the worker in performing each element of the task in question, giving the symbol, size, height, etc., of the machine, bench, table or truck. It is also advantageous to make sketches of the product, showing it before and after the operation with an outline of the position and use of tools. It is far better to record too much than not enough. The abbreviating can best be done when summarizing, indexing and filing finished element times.

There are many methods of observing, recording, and selecting element task times. However, almost all have a close relation to the probability or law-of-average curve. In the case of one method, a series of stop watch readings or elements in repetitive cycles gives a group of element times. From these an average is determined and the minimum selected. The ratio of this minimum to the average time for the element gives a measure of the human factor in the problem, or the variation from one hundred per cent perfection. This is perhaps best explained by saying that if a worker can constantly perform the motion, or group of motions constituting an element, in the minimum time, then the average time and minimum time will be equal. The ratio will be unity and the worker will be literally a machine—an impossible situation.

It is apparent that this ratio of the average to the minimum is the representation of the departure or deviation of the human worker from an imaginary machine performing the motion in the same manner. Such a ratio, or departure of the average from the minimum time, has been found to range between 1.20 and 1.30 for average workers, although this varies to some extent according to the nature of the work being performed. It is well to carefully consider time studies which show ratios of average to minimum times greater than 1.30 before making use of them for setting task times.

When the deviation for each element or part of the cycle of work has been determined, these are totalled and a cycle deviation obtained. The average times for each element are now divided by this cycle deviation and the selected minimum times result. It is these selected minimums for motions, or groups of motions comprising elements, that are now indexed or placed in tabular form for future reference as standard times to be used in making up other groups of elements or task times.

As Mr. Merrick's paper brought out, Mr. Taylor found that it became necessary to apply a percentage allowance to the element times for "the quickest and best method," the latter corresponding to the previously mentioned selected minimum times. He stated that this percentage should vary according to the length of cycle, number of elements and the frequency of repetition.

Since the presentation of Mr. Taylor's paper of 1912 before the American Society of Mechanical Engineers, a number of methods of arriving at these allowance percentages have been devised. One illustration of the method of establishing such a variable allowance curve is described in Chapter 5 of the book "Time Studies as a Basis for Rate Setting" by Mr. Dwight V. Merrick.

When the elements comprising the cycle are summarized, a percentage from such a chart or curve is applied. The result, together with allowances for the unavoidable delays, determines the task time.

Another plan for computing studies is to separate the abnormally high and low element times from those which are the more predominant, and through a series of computations, to determine an allowance for high and low values. This allowance is then added to the average of the predominating element times.

Such a plan does not start with minimum times as a basis. It uses average times and is believed to permit an opportunity for greater error resulting from the influence of the human element of the worker in the problem.

It is a well known fact that almost all the countries of the world very carefully maintain and safeguard their standards of length and weight, and that the people use these as a basis from which all larger amounts are measured by comparison. In like manner, it seems proper that we should use the minimum times as a basis for selecting the best time for the one best method, especially if we have a means for determining the best time by comparison with one hundred per cent perfection.

Operations which consist of cycles of work that are periodically repeated may be studied by being broken down into individual motions or groups of motions, giving elementary times. On the other hand, it often becomes necessary to establish task times on automatic or semi-automatic machines. In this case, the time study takes the form of a production study where the delays are analyzed and, if possible, each delay broken down into its elementary times.

Another form of study is that required when a group of machines performing different operations are assigned to one workman. An example of this is a group of milling machines where each cycle consists partly of handling time—removing the finished piece from the fixture and placing the next one in position, followed by a period of automatic machine feeding. In this case, elementary observations of each machine or operation are made separately. The handling time cycles may then be summarized and plotted on a chart so that it is visually represented that the automatic feeding element of the first machine will end at nearly the same time that the workman has finished the handling time element on the other machines of the group. In most cases, an effort is made to have the first machine finish its feeding cycle and wait for the man rather than arrange the group of machines so that the man is waiting.

When studying machines which require the employment of a number of workers, as for example, large heating or annealing furnaces where groups of men are required to load and remove the material and where a varied heating time is required according to the size and shape of the product, it is advantageous, after making elementary studies of each workman, to arrange a system of units as a basis for assembling and tallying the amount of work done. These units may be minutes, tenths of an hour or some other increment of time. The result of such a plan will be that the individual workers in the group will receive increased payment the higher the total units per man measured over a definite period.

Time study has been regularly used for improving methods, equipment and shop layouts. It is also of value for many other subordinate purposes, such as a basis for estimating and budgeting.

When a complete set of time studied standard times is available for the operations on a product or a representative group of products in a department it is possible to formulate a basis for labor planning, covering both direct and indirect labor. For varied activities of a department or shop the man hours of direct labor for each class may be estimated in advance. Having determined the hours to be worked per day, it is then possible to know how many employes of each class will be needed. This is of particular value when the production program is increasing and there is need for training new workers. On a decreasing production program, such a plan is also of value in order that retainer and idle time payment may be at a minimum.

This method of using time studies as a basis for labor planning requires some study and analysis of the indirect or supervisory labor. For example, it may be found that an overseer should also do the work of an adjuster below fifty per cent activity, or the adjuster should also do the moveman's work, or the foreman should attend to clerical or adjusting work below a certain activity.

After establishing the direct and indirect labor man-hour requirements, it is but one more step to have the table show the extension of the hourly task earnings for each class of labor. From this the ratio of the total direct to indirect labor payroll may be extended for various activities of the department and an effort made to keep the ratio as high as possible. If a production greater than one hundred per cent capacity of the shop is temporarily required, such a labor planning chart can show at what point overtime or increased equipment for certain operations will be required. Increments of ten per cent activity from zero to 100 per cent capacity give a useful scale for labor planning data.

It often happens that methods of job analysis and time study have been carried on in a factory or establishment for several years. As with other groups of employes, costly labor turnover will affect the time study organization and a new group of observers may gradually take over the methods-and-times work. This may mean that the new organization will formulate a plan for changing the method of arriving at selected task times. The result will be that the files of the particular organization will have task times or selected minimum times which have been determined by two or more methods. Such an unfortunate situation may lead to the erroneous use of standard times, or additional expense for obtaining new element times. When starting on job analysis and time study in an organization which has already accumulated a large number of standard times careful consideration should be given before changing the customary plan of study which has been in use.

The standardization of methods for determining element times seems almost as impossible as it did to the manufacturer years ago when he was asked to standardize threads for bolts, etc. However, it is believed that the future will show a way for time study observers to get together and formulate the one best plan of arriving at selected times and necessary allowances. There may also be a central organization or group which will receive, index and file standard data and provide a means for its distribution. Through such a means the effect of climatic conditions on the worker will be studied, making due allowance for the same operation performed in the dry cool climates as compared with the hot ones of high humidity.

Study of Fundamental Operations of a Machine Versus Study of Individual Operations

By G. E. SCHULZ
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Introduction

IT IS the purpose of this paper to consider the values and difficulties of time studies of fundamental operations as compared with the study of individual operations of a machine.

This discussion is therefore limited to the machine or work of the machine. It follows that much of the functioning of a machine may not be a matter of time study observation, but one of engineering or the development of cutting, forming, or molding data. However, time study does apply to both the points of formation of materials on a machine and its manipulation—to various degrees in various industries. The question then is, when the problem is confronted, "What may be expected from the two methods enumerated above?"

But before getting into this, it may be well to develop a sort of classification of machines in relation to the subject in hand. These classifications are:

1. Machines where both the cutting or forming and manipulation are taken care of entirely by power.

2. Machines where cutting and forming are (both speed and feed) taken care of by power, but the general manipulation is controlled largely by man.

3. Machines where the cutting and forming are either in part or to a large extent controlled by man, and also the general manipulation, or where these are pretty much interwoven with one another and controlled by man.

In the first class, into which we may put most of the power operated and controlled continuous operation machinery, the speeds and feeds are established by engineering, either through engineering department research or from previous information on the subject. The manipulation equipment that controls various functions and conveys material is mechanically controlled to the speed of the major purpose of the machine. It may be argued that all such machinery is subject to time study, and very likely time study is useful at times and can show ways of improving the machine itself. The fundamental operations of such machines, both forming and manipulating, are, however, an inherent part of design, which covers speed, feed, manipulation and time for their performance. This is a subject in itself, but it is interesting in passing to call attention to the way in which the time study attitude has been used in engineering.

There are, of course, at times some features of this class of machinery calling for man manipulation and here the question of time study enters in. This feature will be taken up later on.

Now we come to the classification of machines where cutting and forming are taken care of by power, but general manipulation is controlled by hand. The question of time for actual cutting or forming as in Class 1, is controlled by applied engineering.

In other words, it may be said that in cases of man manipulated but power cutting machines the time for the cutting feature may be semi-automatic, or fixed by engineering, and in other cases by cutting data. Where the machine has varied cutting speeds and feeds the time is established from engineering data charts, not from time study.

Here, as in the first class, there are variations from this general rule. At times, where no data are available, time study may be used as a medium of research and establishment of data.

These machines are either manipulated by hand movement or are hand controlled and power moved. The old machine tools, entirely hand moved, and the later designs with power rapid traverse, are good illustrations of these cases.

The question of manipulation is a problem of time study, whether the part is or is not partly moved by power. Those elements of time in the manipulation of machine parts other than cutting action, when served by power, should go back to engineering calculation as a rule, because they depend upon speeds established by machinery.

We now come to Class 3, machines where the cutting and forming are either in part or to a large extent controlled by man. Here time study must function largely. It must decide the correct time for control of cutting and manipulation. It very often leads to research in the cutting or forming operations which in turn at times provides distinct data for these elements.

So far an attempt has been made to present the problem of time study in connection with various classes of machinery. In this presentation it has been brought out in part that engineering in the case of continuous, automatic and semi-automatic machinery covers the problem of time for forming the product, and that in other cases organized data for machines of various speeds and feeds used on a range of products cover the question of time for forming the product.

It is of interest to digress for a moment to think how improvement in machinery during the past fifteen or twenty years has covered much of the field formerly solved by time study or, what is still better, not solved at all. There is a point here that is of especial interest in connection with the subject. Where engineering has rather thoroughly covered items of time in the design of machinery it has learned possibilities of fabrication and built standards of machinery around these possibilities. It may be said that it has developed, through the means of research, possibilities of performance and established machinery to carry out these possibilities. Engineering works from the desirable and possible, not entirely from the existing. Time established by engineering is always closely related to other standards. Is this not a key to the solution of problems of time study? In the development of engineering, where time of forming and manipulation is important, there is no doubt that engineering has learned from the time study of the past. Now, does not engineering point to better ways of time study? Does it not point to the salient principles that should underlie all our time study practice?

Of recent years I have come to view mechanical engineering and other scientific departments as part of the methods function of a plant. They cover a big part of the problem of time for work, and the methods and time study department covers the rest of the methods function. They supplement each other both in present and future problems. There can be little doubt, it would appear, that engineering eliminates the necessity for much time study work.

With this preliminary discussion, which seemed essential to treating the subject with proper qualifications, and in order to clarify just what is the problem of time study on machines, we can proceed to the two methods of studying the work of machines, the time of which is dependent upon time study.

By the study of fundamental operations of a machine is meant, for the purposes of this paper, the separate study of the movement, manipulation and control of the various features of the machine; whereas, by the study of individual operations is meant the study of jobs performed on materials by the machine. Job here refers to an operation performed by some machine on a given piece of material. The first is a study of what the various features of the machine can and should do, and the other a study of what is being done with a view to ascertaining what can be done. One is a close study of an element of work and the other is an overall study.

Naturally at the outset there seem to be advantages for both methods. A superficial observation may, however, be incorrect in sizing up the advantages and disadvantages for both methods.

In the purchase of equipment there are usually the questions, "Where are we going to use it; how long do we want it to last, and is it best to have an early replacement?" Then, too, there is always the question of initial cost and expediency.

These same questions may not in the same sense apply to the methods of time study, but we may well ask at the outset, "What do we expect to accomplish; how far do we want to go, and how soon do we expect to get there?" Once the purpose and aims are established, we should be able to choose the method of procedure. The study of fundamental operations provides a study of extensive reconstruction before establishing times; the other method provides for studying existing times without the purpose of improvement. Either method can be used for a purpose involving limited improvement.

Let us consider the conditions, standards and product of the two methods, and then we may have the answer of advantage or disadvantage in a particular case, for after all the individual is interested in what his selection will provide. The conditions, standards, product and limitations of the two methods will be listed separately, for otherwise it may be difficult to follow through without confusion.

No industrial case, whether it has had time study previously or not, will be followed.

The two methods are treated in the order mentioned in the program of the meeting.

Fundamental Operations of a Machine

In the study of fundamental operations of a machine, a careful standardization of the features of machines, tools, and the devices used on them, is essential to obtain the real advantages of simplification and make possible the extended universal use of time studies. It is also necessary in order to provide standards of maintenance upon which performance is dependent. Some of the objects and problems of establishing elementary time study for fundamental operations of a machine are to establish time study data that will serve for all operations done on a machine for an indefinite period, or so long as the machine is not redesigned; to establish exactly the same time for a given element of work regardless of the machine or the product it is used on.

This form of time study should always be guided by engineering accomplishment in the study of existing machinery, and therefore be a force in the selection of additional new or replacement machinery, and in the standardization of existing machinery. It may well be stated that a first purpose of the study of fundamental operations of a machine is one of selection and establishment of standards. Once standards have been established, making similar parts of various machines and equipment alike, then final studies are made. This necessitates considerable preliminary work. The extent to which poor features of design are shown up is striking.

Under the plan of studying fundamental operations a very effective technique can readily be developed. One small element is studied repeatedly by itself and it is not difficult for the operator being studied to perform this element skillfully. The time study man is able to concentrate, and through the combined efforts of the operator and the time study man, data are developed representative of a high degree of mental and physical dexterity. The skill so developed readily takes on a tempo, which gives a consistency for all study.

This means that time study is not a direct study of methods on products in operation. It is necessary to devise methods out of the data provided. Data so provided permit of constant change and improvement in method. Method is here referred to as any of a number of ways of proceeding with a given machine and tools; with a variation of tools; or with other machinery. It is a mental and physical procedure of doing a job. Fundamental operation time study permits a change in any of these directions. This is one of its big advantages. Industry should be so constructed as to permit constant improvement and time study should be organized to function accordingly.

The feature of equality provided by elementary time study of fundamental operations gives it great importance from the human standpoint. It furnishes an excellent means for training into new work. In the case of a plant that has had day work the jump from old production to new seems out of all reason and therefore involves a real training problem. However, with elements so small that they are readily learned the problem is almost solved.

Individual Operations of a Machine

One of the objects of establishing time study for individual operations of a machine is to establish overall time for jobs done on the machine. These studies are for the particular operation on a product. They may be taken in subdivided fashion and used for other work. If they are not taken with this in view, however, they are usually used to furnish time for a particular job.

Under this plan of time study any condition may be readily studied either with little or considerable improvement. Standardization of similar features of machinery throughout the plant is not necessary, for it is not a purpose to establish universal data. Because of this it may be claimed that this method is quicker and has more general application, especially where conditions are not to be improved. There is, however, a real danger of copying in part the existing method and time for it.

The study of an operation on a job makes possible a connected study of the machine, tool and material manipulation.

The question arises, "Will such a study develop a particularly effective technique for each element of a man's work?" Unusual features of work may be absorbed. At times overall studies absorb the performance of cutting or forming, for which distinct research should be made, in case engineering data do not already exist.

The overall method of study provides a ready means for studying minute operations where it would be difficult to make separate fundamental machine operation studies. By clearly defining the elements of such work elementary data can be developed as well as an overall time provided for the job. The whole study is short and the advantages of the close observation of an elementary study can be obtained.

Under the plan of job study (unless data are developed from it) a new study is necessary with each improvement of method, either general or specific improvement. Unless such studies are made adjustment is difficult and can only be taken care of in an arbitrary way. Some industrial engineers claim, because of improved devices and technique, that studies are only good for a period of about a year. The importance of restudy, unless careful study has been accomplished at the outset, is at least emphasized. This is a considerable subject in itself and can hardly be treated in the limits of this paper. One thing is certain, and that is that provision needs to be made for technique, general improvement, and specific improvement in devices. In order to cope with improvements under any conditions, the influence of time study should be constant.

It has already been suggested that overall studies at times readily permit the study of material handling in connection with machinery.

The study of individual operations is also more readily applicable in some cases of group operations.

The advantages of the two methods and the problems attending them, both previous to and after time studies, may be summed up as follows: The study of fundamental operations of a machine, or the detailed separate study of various elements and of the connected work, provides data for any method and therefore covers constant improvement; requires standardization previous to study and maintenance; is in close harmony with an engineering approach and in most instances calls for distinct data for cutting and forming; approaches the engineering idea of continuous machines and time for engineering standards established; necessitates separate method provision in arranging and setting time for a method; provides at the outset data representative of a highly effective technique; provides the same time for an element of work regardless of where that element is performed, and thus gives a basis for equality and change. It also provides a very clear cut employer-employe relation on the question of rates.

The study of individual operations done on a machine provides time directly for an operation on a product; provides for some correction and standardization of conditions, but does not necessitate overall standardization. The study can be made under almost any conditions and therefore gives a quicker start and correspondingly quicker results. In many instances it covers forming and cutting; it gives a connected study of work which at times absorbs unusual conditions; it is a study of what is being done with a view to correction; it calls for additional studies with improvement in conditions and the consequent adjustments in rates, which in the end means the study of the same element over and over again. This is necessary under this plan of time study, but gives various times for the same element of work. Over a period of years, in order to obtain the same results as under the plan of fundamental studies, a greater amount of study is necessary.

Because of the wide range of work in industry, including continuous work of very minute times, continuous work of large elements of time, and non-continuous work, both methods of study are at times used jointly. That is, the continuous method may be used to develop elementary data, and vice-versa, the fundamental to develop overall times.

Conclusion

I trust that the question of the technique that the time studies of the one method give, and how long it will take under the other method to reach this technique, and also the question of what is reasonable from the human standpoint and most apt to give results, will receive attention and call forth discussion here.

It is my belief that time study and what it aims at—facts—can be, and are in many instances, the strongest link between employer and employe. Time study should give that integration in industry that we often look for, for it is a strong human influence when properly exercised. What time study will do for the individual in a moral way should be of major interest. If I had been permitted to choose I should have preferred to give that side the same emphasis as the mechanism of time study. The work of moral influence should be an integral part of the objects of time study and should go hand in hand with its development. It would be desirable, I believe, if in all time study presentation the human relations could be treated as an integral part.

In this age of mechanization of industry and the study of the mechanism of Nature's laws it appears that, if the moral features are not kept in the foreground, they are apt to be neglected or lost to the worker. The scientist who follows his text in his research no doubt has the ability to see the moral law as well as the mechanism of laws, and thereby receives double remuneration.

Is it a surprise that F. W. Taylor in his intensive study of production and the sciences involved should have been the first to include in "The Principles of Scientific Management" the development of a science for each element of a man's work, and at the same time include the question of employer and employe relations—that subject of human engineering we hear so much about? They were one and the same to him.

As an illustration of the educational and moral force of time study well constructed and applied, an early contribution by Colonel H. K. Hathaway stands out. He learned that he could take a large crew of men on a job and train them for work that called for both mental and physical dexterity, by the adoption of uniform standards arrived at by time study. He also repeatedly pointed out that time study, once taken properly, will stand for an indefinite period and has indicated this in some of his writings. The significance of this early work is still lost to many an educator and engineer. It is of the essence of time study and methods training.

Unit Times Versus Overall Times

By **EARL E. WATSON**
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AFTER considering the printed program of this meeting, it appeared to me improbable that anyone interested in the purpose of the Taylor Society, or in the principles and practices of time study engineering, to the extent that he is in attendance at this meeting, should need any explanation of the relative merits of unit or elemental times and overall times. But, possibly, a review of the subject may prepare for the papers to follow.

Unit times are considered to be the times taken or required to complete a given motion, element or subdivision of a complete operation.

Overall times are recorded times for the operation as a whole.

It would be useless to enter into a discussion of my subject without first touching upon the object of any system of task time measurement. Dr. Taylor, in his "Shop Management" has defined the art of management as "knowing exactly what you want men to do, and then seeing that they do it in the best and cheapest way." All systems of time study are designed, primarily, to advance the knowledge of what constitutes a day's work. It follows that the method which results in the most complete analytical information is the most effective.

Overall times, beyond establishing as a fact a time actually taken to complete a given task, add nothing to the "art of management." Such times, affording no possibilities of analysis, do not uncover improper or useless methods or lead to the development of a permanent "best and cheapest way." Dependent entirely either upon the judgment of an observer or the performance of an individual, they are obviously quite apt to be unfair to management, labor, or both.

On the other hand, unit times, compelling the observer to analyze the elements of a given task, automatically force consideration of the method involved and, as Mr. A. B. Segur has said in a recent paper on "The Mission of the Engineer in Relation to Motion Time Studies,"[a] "So far as time required is concerned, the job is fully ninety per cent method and not over ten per cent physical effort." Unit times enable the analyst to pick out, measure and eliminate useless and inefficient elements. Unnecessary or unusual delays are made apparent and are possible of correction. Remaining elements of the operation may be grouped and regrouped until the best possible combination has been arranged and tested and compared with similar elemental times for other operations and other workmen.

It may be advanced in the discussion to follow that elemental or motion analysis is not impossible under the overall time method. That the observer may consider and correct inefficiencies while making the observation, and reflect that correction in his final observed times is possible. But, granting the possibility, the life of the improved method is limited to the employed term of the workman observed. No descriptive record is established to perpetuate the method.

Unit time, on the other hand, captures the skill and the method of the best workers and makes it permanently available. Dr. Taylor prophesied the day when fundamental times would be established for almost every class of labor and made a matter of record. Engineers, notably the Gilbreths and Mr. A. B. Segur, have gone far towards advancing that day by the discovery of basic principles and underlying laws governing all motion. It remains for other engineers to apply such laws to standard and carefully considered methods of operation, and to classify and compare elemental operations and unit times. Already much has been done along this line and accepted standard unit times covering many different classes of work have been established. Too often, however, so-called time study is used solely for the purpose of establishing a piece work or bonus rate and, in the eyes of a short sighted management the time study engineer's value is proportionate only to the number of rates determined in a given time. Management must be made to see clearly that today reduced costs are to be expected, not so much as the result of any particular wage incentive plan, but rather, as the result of better methods determined by sound analytical time study practice. And only by such practice can time study hope to become a scientific guide to "the best and cheapest way"—"the best and cheapest way" to reduced production costs, and to advance labor.

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[a] *Society of Industrial Engineers Bulletin*, Vol. 8, No. 10, October, 1926, p. 9.

Classification, Filing and Use of Time Study Data

By STEWART M. LOWRY
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BEFORE entering upon a discussion of the subject assigned to me, I wish to take a moment to congratulate the directing heads of the Taylor Society on their selection of "Time Study" as the general subject for this convention. They have visualized the heart of scientific management. Take the element of time measurement out of scientific management and what remains to hold the various branches of the science together? Planning, scheduling and routing could not justifiably exist, certainly could not function efficiently, without accurate knowledge of the time required to do things. Improvements in manufacturing methods would develop much more slowly, and many never would develop, without the aid of time study. After all, assuming the result to be the same in each case, how can one method be said to be better than another, from a purely economic standpoint, except as it saves time.

Secondly, I desire to express my sincere appreciation of the invitation to participate in your meeting with full recognition of the honor which accompanies that privilege.

In approaching the subject which has been assigned to me, "Classification, Filing and Use of Time Study Data," I shall assume that the time study has been made according to an approved scientific method and that the elemental values secured are correct. Much of the discussion which has preceded this paper has been, and some to follow it will be, concerned with time study technique—how to make reliable time studies. I shall endeavor to confine myself to consideration of how best to use the data thus secured.

It is recognized that time study is useful in laying out schedules, prediction of costs, determination of equipment capacities and so on. By far its most important usefulness, however, or at least that in which it has had most extensive application, is on wage incentive work. For the purposes of this discussion, I shall consider only this application.

Many time studies are made with no other object than to establish a time value for the one particular job under consideration, and with this done, there is apparently no other immediate use for them. They are accordingly filed away against the time when some future use for them may develop.

This file should be maintained so that the individual time studies may be readily found for reference purposes. There are various methods of filing time studies, depending upon local plant conditions and subdivisions of manufacturing operations. In one case, it may be best to file studies by the departments in which the work was performed; in other cases, classification according to classes of work or types of machine tool equipment may be best.

This file will be comprised largely of miscellaneous studies on various lines of work on which sufficient studies have not been made to make possible the compilation of standard data or the construction of a formula, because of the low activity of the work or because of an insufficient number of trained time study men in the organization to do more than take care of immediate pressing demands. Some of the individual studies will probably be independent of and have no relation to the others, having been made with no other object than to determine a time allowance for one particular job. To make a time study with this single purpose in view may be justifiable, and it may even be justifiable to do it again and again, but if there are frequent repetitions on similar jobs that fall in the same general class of work, the uses of the data secured from representative studies may be extended to cover the entire class of work. This may be done by compiling standard data or by constructing formulas by which the time value may be readily determined for any job in the class, without the necessity of actually making a separate time study.

A compilation of standard data is merely a list of all the different elements that have occurred in all the time studies made on a given class of work and the corresponding time values for each. Every element that differs even slightly from every other element has its own time value. When a job comes up on which no time value has been previously established, the standard data are referred to and a time value selected for each of the elements of the job. It is generally necessary to go on the floor and make an analytical motion study in order to determine the elements that are required for the operation. It may be found that some of the elements of the jobs are not included in the standard data because they had not previously occurred in any of the studies from which the list was made. In this case, those elements should be studied or values interpolated from available data and included in the standard data.

The standard data method is frequently used to advantage on machining operations where a considerable part of the time for the operation is cutting time, which can be calculated from the speed, feed, and depth of cut. A list is generally made up for each type of machine tool, and this list includes values for the various motions necessary for the manipulation and operation of each particular machine. In other words, a study is made of the machine rather than the work. The merit in this plan is readily seen when one considers that the piece upon which the work is being done will have little, if any, influence on the time required to manipulate the different parts of the machine, because they have a definite mechanical relation to each other. For example, such elements as "start machine," "stop machine," "release power feed," "remove tool," and "adjust stops" probably will require the same amount of time regardless of differences in pieces being worked upon. The work that can be done on a particular machine tool is limited by the physical characteristics and dimensions of the machine. Hence, it is logical that the machine itself should be made the basis of study on work of this kind rather than the piece or part being made.

I have in mind a particular set of standard data which was compiled for setting time values on sensitive drill press operations. It includes time values for all elements that might be performed in making set-ups and in drilling and tapping cast iron, steel or brass parts, using either carbon steel or high speed steel tools. Thus it is possible to establish time values by merely noting what elements must be performed, determining the number, size and depth of holes drilled and applying the appropriate standard values.

Where the variation in time required is chiefly influenced by physical characteristics of the work, of which there may be innumerable combinations, it is frequently found that formulas furnish better mediums for the most advantageous use of time study data.

A formula may be defined as the expression of a general fact, rule, or principle by algebraic symbols. It is a convenient way of expressing the manner of variation between two or more interdependent variables. When all but one of the variable quantities are known for a given set of conditions, it is quite easy to find the unknown quantity by substitution in and solution of an algebraic formula. It must be remembered that the formula is only a convenient way of expressing a rule and is not the rule itself. In using formulas in general, there is a tendency to substitute and solve blindly, without first examining the rule expressed by the formula and ascertaining whether or not it is applicable to the case under consideration.

The algebraic formula was probably first confined to the field of mathematics. Its convenience and conciseness were readily apparent, and it was naturally extended to physics, mechanics, electricity, and all branches of applied science. Hence, we are not surprised to find it in time study.

When time study was first introduced into industry, a separate study was taken on each job as it came along. This required considerable time and effort and led to the feeling that time study could be applied only to standard lines of work where quantities were large and operations few. It is readily conceivable that the taking and working up of time studies on work of a varied nature might require nearly as many time study men as operators.

It is by no means necessary, however, to time study every job that comes through the shop. Time-study men were quick to recognize that certain elemental operations in a given class of work were constant, regardless of the nature of the piece upon which work was being done. Other elemental operations varied with certain characteristics of the work.

The recognition of these facts led to the compilation of standard data. It then became apparent that certain operations were performed on every piece worked, that others were performed when the piece had certain characteristics, and that the time for doing still other operations varied in a definite manner with certain variable characteristics such as length, area, or volume. The next step, that of resolving standard data into algebraic formulas, followed as a matter of course upon the realization of these facts.

The great amount of time which the use of formulas will save is readily apparent. The time required to take and work up a time study on repetitive work will be from one to four hours where the length of the operation cycle is fairly small, and may be much longer on larger work where one operation cycle may run as high as one hundred hours. The time required to set a time value from a formula will, in the majority of cases, range from one to fifteen minutes, depending on the complexity of the formula and the amount of time required to determine the characteristics of the job. Where all necessary information is obtainable from the drawing of the part, the time value may generally be computed in less than five minutes.

With so much time saved in the work of the time study department, it is obvious that formulas will enable fewer men to cover a given amount of work or the same number of men to handle a much larger territory. The caliber of men required to apply formulas need not be so high as that of men who must take time studies. It is thus possible for a plant to have a few expert time study men who will make the time studies and compile all formulas. The rest of the work, that of setting time values from formulas, may be carried on by men better fitted for routine work and incidentally commanding less salary.

Formulas have made possible the application of time study methods and incentive plans to the job shop. Without them the cost of establishing time values would offset the savings which incentive plans produce, great as they are. With formulas, a large volume of time values may be set by a comparatively few time study men with a large net saving to the plant. Indeed, formulas are highly profitable on all but strictly standard work where operations are so few that it would take longer to compile formulas than to set values by actual time studies.

Where all time values are set by time study, some inconsistencies are almost certain to appear. Because of errors in judgment, unnecessary work that was allowed to pass unnoticed, and variations in the judgment of several time study men who handled the work over a period of time, some time values will be easier to meet than others. Simple jobs will, in some cases, have higher time values than much harder jobs upon which more work must be performed. Such inconsistencies tend to decrease the respect of the workers for time study and time study methods. It takes but one or two "wild" values to shake the confidence that hundreds of correct values have built up.

The only chance for inconsistency when time values are set by formula is in an error in determining the variables which will be substituted in the formula or in the mathematical solution of the formula. Usually such slips will give time values so far out of line that the time study man will see at once that he has made an error and will check his work. If a wrong value does get as far as the worker and he complains, it is a simple matter to recheck the job and determine whether or not the complaint is justified. Once the worker has been satisfied with the fairness and accuracy of a formula, he will very seldom ask for a recheck of a job unless he is reasonably sure that an error has been made.

It is thought by some who have but a superficial knowledge of formula work that formulas can be applied only to machine work where feeds, speeds, depth of cut, and the like are the only variables. The fields in which formulas have been successfully applied are, however, very much broader than that. Practically any line of work may be formulated accurately if sufficient data are first collected. This statement may appear rather broad to those who have not dealt intimately with formulas, but consider for a minute some of the operations upon which time values are being set daily by formulas, as represented by the following: all kinds of machine work; bench fitting and assembling; wiring; bench, machine, and floor molding; bench and machine core making; casting cleaning; foundry furnace work; arc welding; drop forging; chipping with air hammer; coil winding, taping, and insulating; copper forming (miscellaneous); motor assembly; structural steel assembling; painting; window washing; janitor work; maintenance work; wooden box making; storeroom work; tool making, and pipe fitting.

These examples should suffice to show the practically limitless scope of formulas.

The first step in compiling a formula is the making of a general analysis of the work to be covered. This analysis is similar to that made when taking an individual time study, but it is somewhat broader in that it covers the class of work as a whole and not merely the individual job that is being worked upon.

After a clear idea has been formed of what the formula will cover and what work its construction will entail, the next step is the actual collecting of data. This consists of taking detail time studies on a number of representative jobs.

There then comes the task of classifying each individual elemental operation as either a constant or a variable. Just which it is is not always readily apparent, and it requires a man of no little analytical ability to do this work. After the elemental operations have been classified, it is necessary to select a definite time value for each elemental constant and to make a further analysis of each elemental variable to determine just how and with what it varies.

When all constants and variables have been determined, there remains only the task of expressing the formula in its simplest terms and making a report which will explain clearly the construction and application of the formula.

Discussion

Eugene Bouton.[4] Very few people outside the time study profession realize how low the average efficiency of human endeavor is. There is always a limit or breakdown point in any process, either mechanical or manual. There has been more effort directed toward machine efficiency, however, than toward human efficiency.

The breakdown point of machines can nearly always be predetermined but there are more difficulties encountered in predetermining the limitations of an individual. Men are quick to originate and adopt the ideas of others in things mechanical, so that the same standard designs, methods and performances occur in widely scattered localities. Analysis of steel, coal, wood, etc., will give the best grade for any purpose desired. To apply this analogy to individuals is difficult as there are few keen observers who can analyze men and predetermine their capabilities. Individuals have different characteristics and different traits. The most common is ambition or desire for success.

In dealing with the fundamentals of individual operations we have all of the human characteristics to cope with. Men are hired for certain occupations because they claim to be fitted for them, but in reality very little is known of their capabilities and aptitudes.

When assigning work to machines, the fundamentals of operations are carefully studied and the right machine is selected to do the job. In those branches of industry where machine methods have been introduced, many agencies which are not to be classed as mechanical have been drawn into the process and have become integral factors in it. Chemical properties of minerals are counted in the carrying out of metallurgical processes, with much the same certainty and effect as are the motions of those mechanical appliances with which the minerals are handled. The sequence of the process involves both in a very intimate interaction. Wherever manual operations have been supplanted by a reasoned procedure, on the basis of systematic knowledge of the forces employed, there mechanical industry is to be found.

A comparison with individual effort might be made in the field of athletics. On a baseball team, all men cannot be pitchers or fielders. In things mechanical certain grades of steel will remove more cubic inches of metal than others. Many machines of some particular type, for example, milling machines, will vary in their productive output. The rigidity of the machine, its general design and its control features, as well as the power factors, govern its output. The fundamentals of men and machines, therefore, require considerable study.

Standardization of machines and processes has had a very real effect on cost reduction in manufacturing. Manual operations have been supplanted in many instances because of standardization, which was impossible with individual effort. Certain standards of units of measure and weight have been adopted legally. Engineering societies have standardized on materials and processes to some extent and these standards are accepted by industry. The legal adoption of weights and measures and the standardization of materials and designs have been effected after thorough research and, in my opinion, the progress of this engineering endeavor has been the means of eliminating a large percentage of individual effort. Because of the inefficiency of human effort, machinery, with its possibilities of standardization, has extensively supplanted manual operations in manufacturing.

Mr. Darrow, in a debate with Rabbi Brickner of Cleveland, claimed that a man was a machine possessed of a heart, lungs, mind, nervous system, etc.

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[4] Chandler-Cleveland Motors Corporation, Cleveland, O.

He did not point out, however, that there was no way in which his capabilities could be predetermined.

I should like to give one example to bring out my point that there are important variations in the fundamentals of machine operations, as well as in the fundamentals of individual operations.

The Fellows Gear Shaper is a machine used in the automotive industry for producing transmission gears. Many of you are familiar with its operation. There are three feeds on the machine—fine, medium and coarse. The factor for figuring machine time is 700 strokes per revolution for the coarse feed, 1000 for the medium and 1400 for the fine. Let us assume that we are going to cut a twenty-four tooth gear, using a three inch pitch diameter cutter of six pitch, and using a speed of 200 strokes per minute. A six pitch three inch diameter cutter would have eighteen teeth. We will now figure the machine for one revolution of the blank. Using the fine feed, we get

$$\frac{24 \times 1400}{18 \times 200} = 9.33 \text{ minutes}$$

The time is 9.33 minutes for this set up.

Now let us assume that we are going to cut the same gear using the same speed and the same feed, but using a four inch pitch diameter cutter. We then get

$$\frac{24 \times 1400}{24 \times 200} = 7.00 \text{ minutes}$$

The time in this case is seven minutes.

This is a typical example of a fundamental which must be reckoned with in machine operations. We used the same feed and the same speed in both instances. The only difference was that a larger cutter was used in the one case. This, however, produced a twenty-five per cent difference in time.

The variations in the fundamentals of individual operations are not so easily determined. The application of good common sense to both machine and individual operations, however, brings out useful information. Theories must not be carried too far in dealing with these problems.

Allan H. Mogensen.[5] First, I want to congratulate Mr. Lowry on his excellent paper and to express agreement with his general propositions. I feel, however, that his statement, "When time study was first introduced into industry, a separate study was taken on each job as it came along," does not give proper credit to the man for whom this Society is named. It will be found that the establishment of synthetic times was the very aim Mr. Taylor had in mind in breaking down an operation into its simple elementary movements.

At a meeting of the American Society of Mechanical Engineers in Detroit in 1895, Frederick W. Taylor stated, "Practically the greatest need felt in an establishment wishing to start a rate fixing department is the lack of data as to the proper rate of speed at which work should be done. There are hundreds of operations which are common to most large establishments, yet each concern studies the speed problem for itself, and days of labor are wasted in what should be settled once for all, and recorded in a form which is available to all manufacturers. What is needed is a handbook on the speed with which work can be done, similar to the elementary engineering handbooks. And the writer ventures to predict that such a book will not be long in forthcoming."

As brought out by Mr. Merrick, again in 1912 Mr. Taylor stated that time study consisted of two broad divisions, first, analytical work, and second, constructive work. He defined the latter as follows: "Add together into various groups such combinations of elementary movements as are frequently used in the same sequence in the trade, and record and index these groups so that they can readily be found. From these records, it is comparatively easy to select the proper series of motions which should be used by a workman in making any particular article, and by summing the times of these movements, and adding the proper percentage of allowances, to find the proper time for doing almost any class of work."

It may be seen from this that from the start Taylor had in mind, and put into practice, the very principles that we are discussing here.

The manufacture, or processing, of any article may be divided into two classes, namely, (1) that for which the exact method of procedure is known in advance; (2) that for which the exact method of procedure is not known. Therefore, in using the fundamental operations of a machine as a basis for synthetically building up the standard times for an operation, these two classes must be considered separately.

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[5] Assistant Professor Industrial Engineering, University of Rochester, Rochester, N. Y.

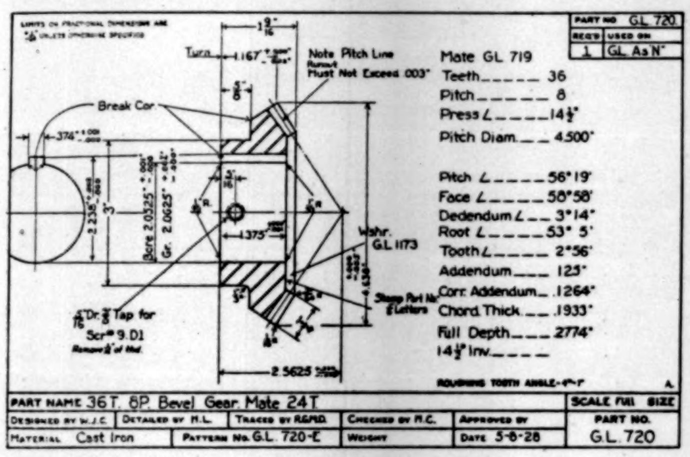


Figure 1

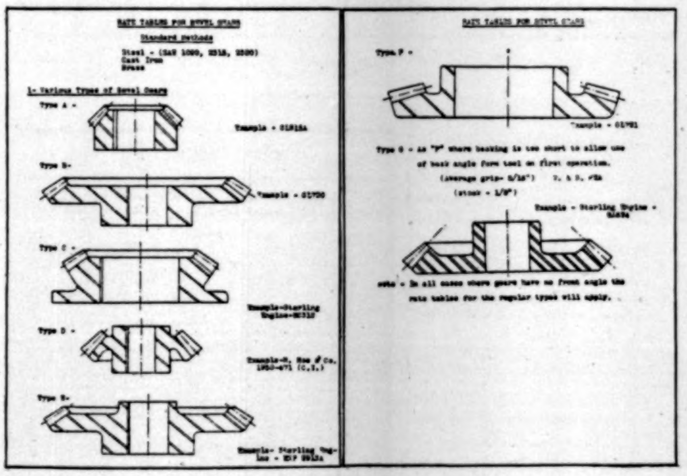
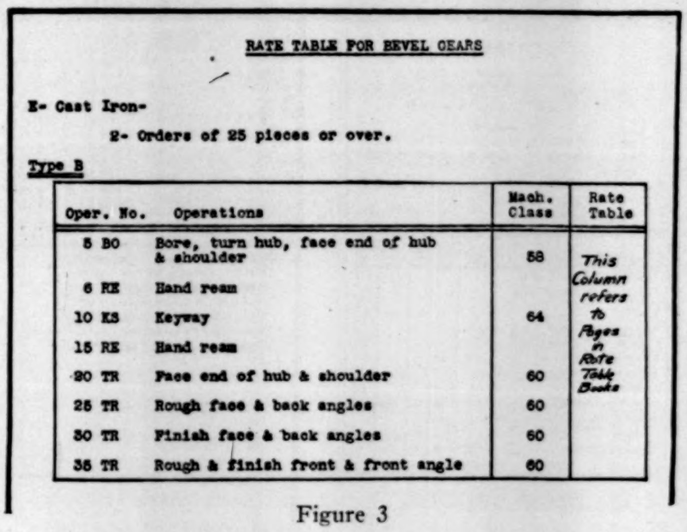


Figure 2

To illustrate the first method, I have formulated an example showing how the operation times would be computed in the case of a concern manufacturing gears to order. Assume that a request has been received for a price quotation for 250 gears as shown on the drawing in Figure 1. All bevel gears can be placed in one of seven classes, or types, and reference is then made to the chart illustrating these (Figure 2). It will be seen that the gear falls in the second group, Type B. Reference is then made to the operation sequence chart (Figure 3), for gears of Type B, cast iron, and to be made in a quantity of over twenty-five pieces. The chart gives the operation numbers, operation names and classes of machines upon which the operations are to be performed. Take the first operation, 5 B O—bore, turn hub, face end of hub and shoulder. It is performed on Machine Class 58, a Jones and Lamson Machine Company Double Spindle Hartness Flat Turret Lathe (Figure 4).

For this machine, studies of the type discussed by Mr. Schulz and Mr. Lowry have been made, giving all the fundamental operations for the lathe, and the unit times. Listed here are the handling, tool setting and machine setting and starting times (Figure 5).



RATE TABLE FOR BEVEL GEARS

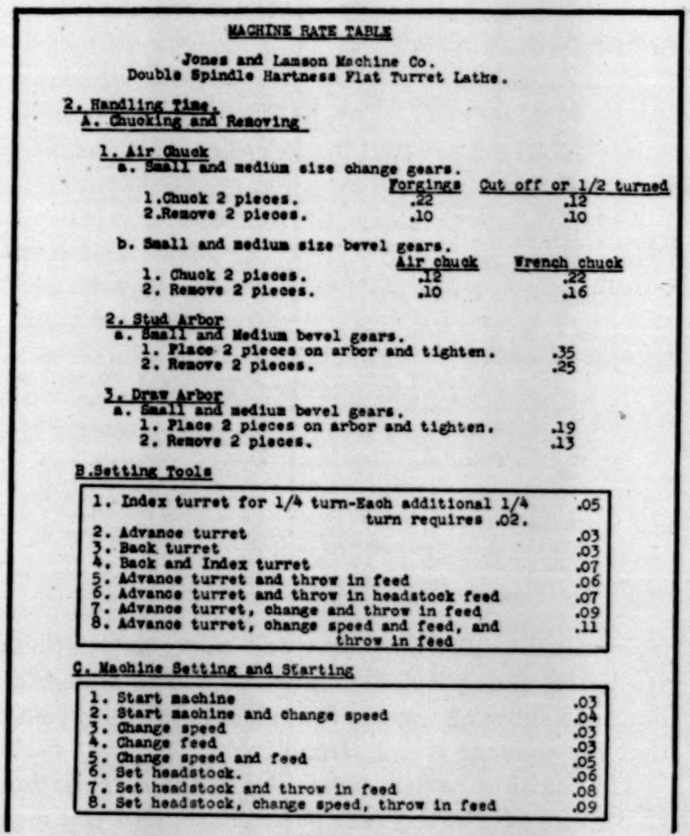
E- Cast Iron-

2- Orders of 25 pieces or over.

Type B

Oper. No.	Operations	Mach. Class	Rate Table
5 BO	Bore, turn hub, face end of hub & shoulder	58	This Column refers to Pages in Rate Table Books
6 RE	Hand ream		
10 KS	Keyway	64	
15 RE	Hand ream		
20 TR	Face end of hub & shoulder	60	
25 TR	Rough face & back angles	60	
30 TR	Finish face & back angles	60	
35 TR	Rough & finish front & front angle	60	

Figure 3



MACHINE RATE TABLE

Jones and Lamson Machine Co.
Double Spindle Hartness Flat Turret Lathe.

2. Handling Time.
A. Chucking and Removing

1. Air Chuck
a. Small and medium size change gears.

	Forgings	Cut off or 1/2 turned
1. Chuck 2 pieces.	.22	.12
2. Remove 2 pieces.	.10	.10

b. Small and medium size bevel gears.

	Air chuck	Wrench chuck
1. Chuck 2 pieces.	.12	.22
2. Remove 2 pieces.	.10	.16

2. Stud Arbor
a. Small and Medium bevel gears.
1. Place 2 pieces on arbor and tighten. .35
2. Remove 2 pieces. .25

3. Draw Arbor
a. Small and medium bevel gears.
1. Place 2 pieces on arbor and tighten. .19
2. Remove 2 pieces. .13

B. Setting Tools

1. Index turret for 1/4 turn-Each additional 1/4 turn requires .02.	.05
2. Advance turret	.03
3. Back turret	.03
4. Back and Index turret	.07
5. Advance turret and throw in feed	.06
6. Advance turret and throw in headstock feed	.07
7. Advance turret, change and throw in feed	.09
8. Advance turret, change speed and feed, and throw in feed	.11

C. Machine Setting and Starting

1. Start machine	.03
2. Start machine and change speed	.04
3. Change speed	.03
4. Change feed	.03
5. Change speed and feed	.05
6. Set headstock.	.06
7. Set headstock and throw in feed	.08
8. Set headstock, change speed, throw in feed	.09

Figure 4

Referring to the master operation sheet for Type B bevel gears, of cast iron from four to eight inches in diameter, the operation as performed on the Jones and Lamson machine is broken down with its elements, all times for machine manipulation being given, totalling one and one-half minutes. The average depth of cut and the proper speed and feed are also listed and the cutting times computed from them. The formulas for the computations are listed under No. 3 (Figure 6). The computations are shown here, the first machining time being that for element No. 3 "Drill."

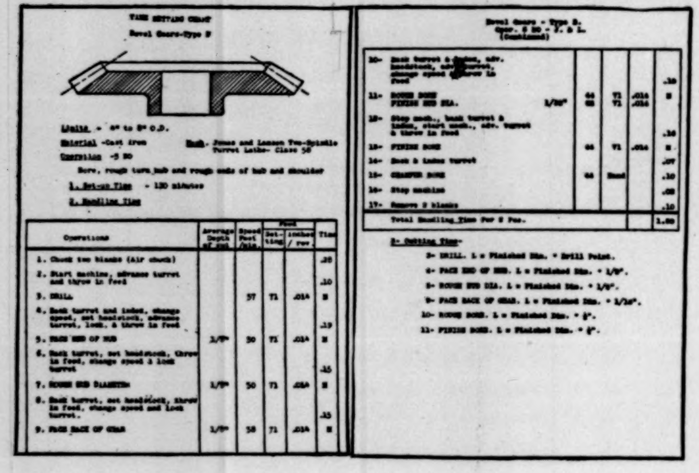


Figure 5

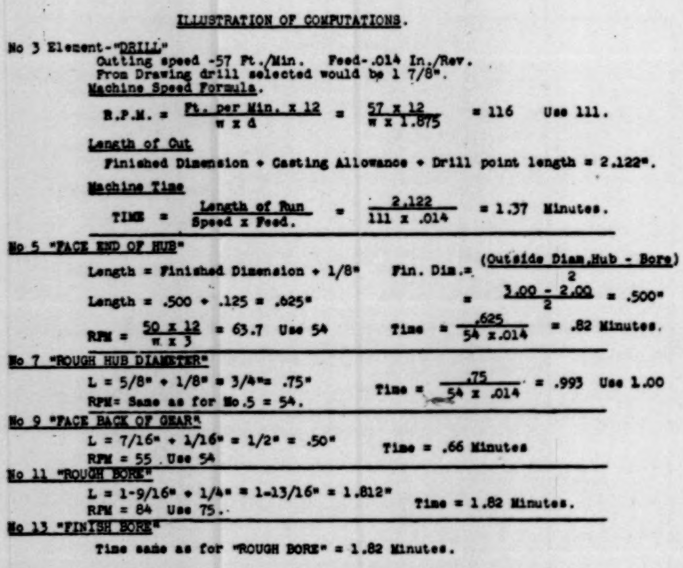


ILLUSTRATION OF COMPUTATIONS.

No 3 Element-"DRILL"
Cutting speed -57 Ft./Min. Feed-.014 In./Rev.
From Drawing drill selected would be 1 7/8".
Machine Speed Formula.

$$\text{R.P.M.} = \frac{\text{Ft. per Min. x 12}}{\pi \times d} = \frac{57 \times 12}{\pi \times 1.875} = 116 \quad \text{Use 111.}$$

Length of Cut
Finished Dimension + Casting Allowance + Drill point length = 2.122".
Machine Time

$$\text{TIME} = \frac{\text{Length of Run}}{\text{Speed x Feed.}} = \frac{2.122}{111 \times .014} = 1.37 \text{ Minutes.}$$

No 5 "FACE END OF HUB"
Length = Finished Dimension + 1/8"

$$\text{Fin. Dim.} = \frac{(\text{Outside Diam. Hub - Bore})}{2} = \frac{3.00 - 2.00}{2} = .500''$$

Length = .500 + .125 = .625"

$$\text{RPM} = \frac{50 \times 12}{\pi \times 3} = 63.7 \quad \text{Use 54} \qquad \text{Time} = \frac{.625}{54 \times .014} = .82 \text{ Minutes.}$$

No 7 "ROUGH HUB DIAMETER"
L = 5/8" + 1/8" = 3/4"= .75"
RPM= Same as for No.5 = 54.

$$\text{Time} = \frac{.75}{54 \times .014} = .993 \quad \text{Use } 1.00$$

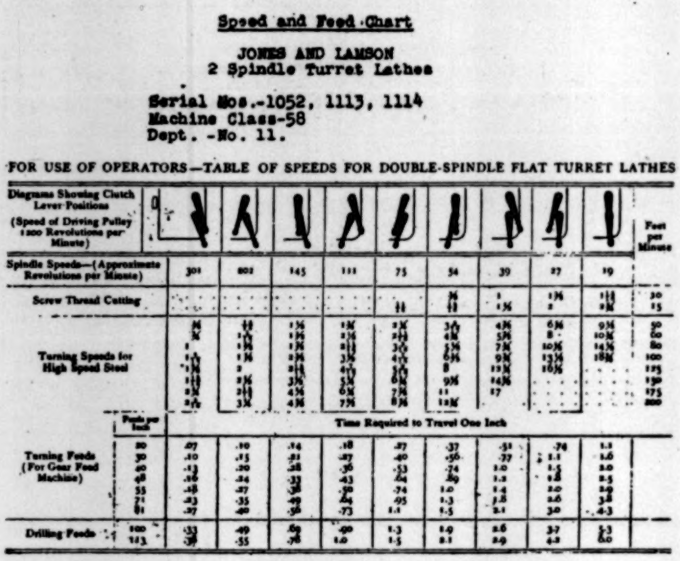
No 9 "FACE BACK OF GEAR"
L = 7/16" + 1/16" = 1/2" = .50"
RPM = 55 Use 54
Time = .66 Minutes

No 11 "ROUGH BORE"
L = 1-9/16" + 1/4" = 1-13/16" = 1.812"
RPM = 84 Use 75.
Time = 1.82 Minutes.

No 13 "FINISH BORE"
Time same as for "ROUGH BORE" = 1.82 Minutes.

Figure 6

The cutting speed from the master operation chart was fifty-seven feet per minute, and the feed .014 inches per revolution. Substituting in the machine speed formula, we get 116 revolutions per minute, but by reference to the Jones and Lamson speed chart (Figure 7), it is found that the nearest speed is 111 revolutions per minute. This is then used in Figure 6. The length of cut is the distance this drill must travel, plus the allowance for the drill point length, found in the table given in Figure 8. Here also are given the speeds and feeds for drilling. Thus the length of cut is determined in Figure 6. The machine time computation is made by substituting in the formula, the result being 1.37 minutes (Figure 6).



Speed and Feed Chart

JONES AND LAMSON
2 Spindle Turret Lathes

Serial Nos.-1052, 1113, 1114
Machine Class-58
Dept. -No. 11.

FOR USE OF OPERATORS—TABLE OF SPEEDS FOR DOUBLE-SPINDLE FLAT TURRET LATHES

Figure 7

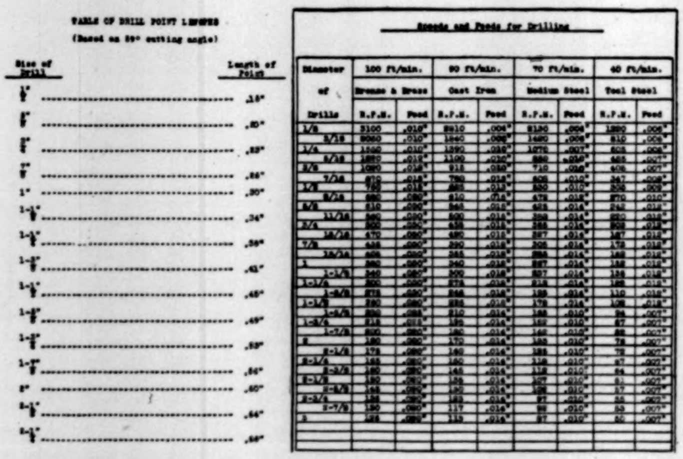


Figure 8

These computations may be very greatly simplified by using the Barth slide rules, the settings for the previous computation being shown in Figure 9.

The remainder of the computations are made in the same manner, and the total machine or cutting time adds to 7.49 minutes. This, totalled with 1.50 minutes handling time, gives the base time, to which the necessary allowance is added, thus giving the standard time.

This is used in making out the cost estimate, and when the order is received, as a basis for scheduling. Standard instruction sheets are available (Figures 10 and 11), in blue print form, so that with the scheduling of the job these can be filled in with the machine times and sent to the respective departments. In this manner, where the method is known in advance, the time study and instruction card have actually been made out before the job is started through the plant.

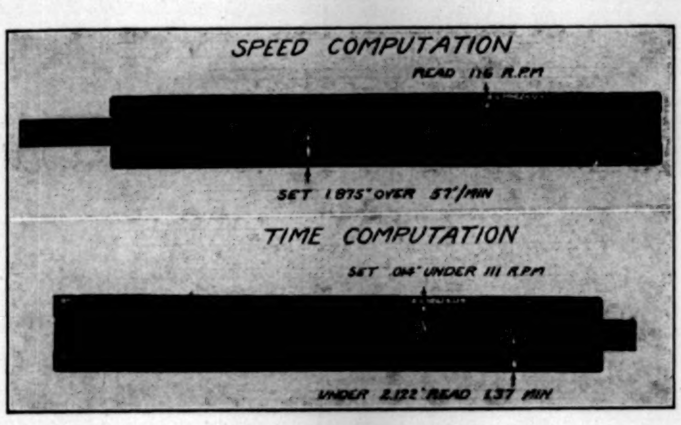
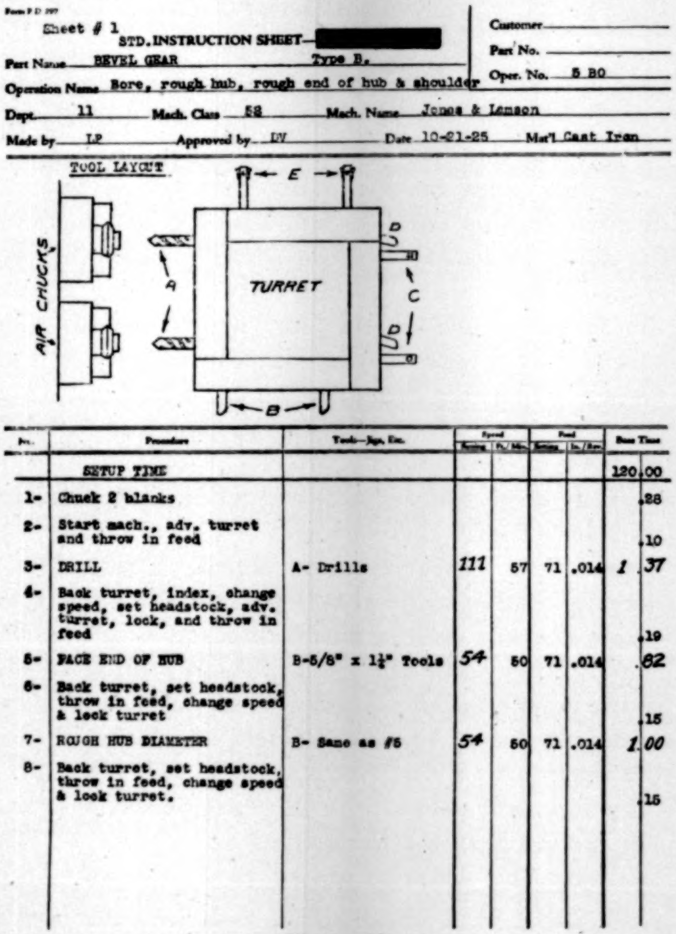


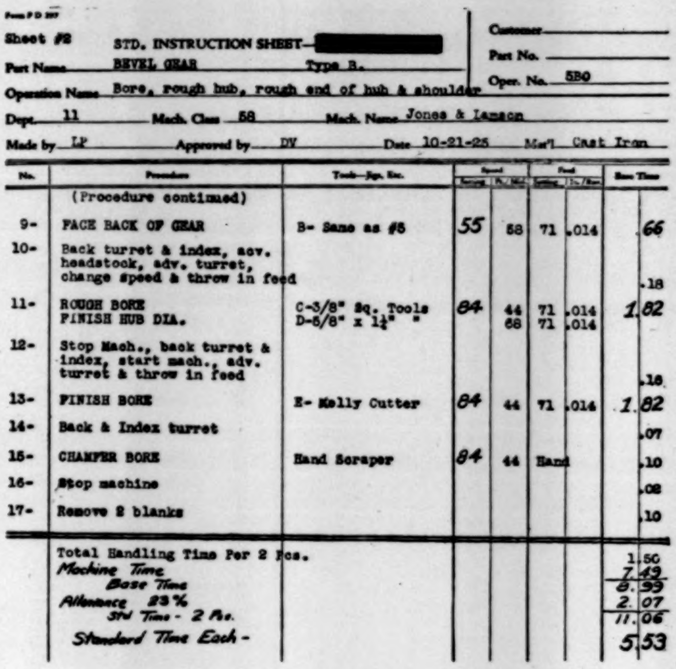
Figure 9


TOOL LAYOUT
E
D
C
D
A
TURRET
AIR CHUCKS
B

Form P D 207
Sheet # 1
STD. INSTRUCTION SHEET—[redacted]
Customer
Part No.
Part Name BEVEL GEAR Type B.
Operation Name Bore, rough hub, rough end of hub & shoulder
Oper. No. 5 BO
Dept. 11 Mach. Class 58 Mach. Name Jones & Lamson
Made by LP Approved by DV Date 10-21-25 Mat'l Cast Iron

No.	Procedure	Tools—Jigs, Etc.	Speed Setting	Speed Ft./Min.	Feed Setting	Feed In./Rev.	Base Time
	SETUP TIME						120.00
1-	Chuck 2 blanks						.28
2-	Start mach., adv. turret and throw in feed						.10
3-	DRILL	A- Drills	111	57	71	.014	1.37
4-	Back turret, index, change speed, set headstock, adv. turret, lock, and throw in feed						.19
5-	FACE END OF HUB	B-5/8" x 1½" Tools	54	50	71	.014	.82
6-	Back turret, set headstock, throw in feed, change speed & lock turret						.15
7-	ROUGH HUB DIAMETER	B- Same as #5	54	50	71	.014	1.00
8-	Back turret, set headstock, throw in feed, change speed & lock turret.						.15

Figure 10



Form P D 207
Sheet #2 STD. INSTRUCTION SHEET—[redacted]
Customer
Part No.
Part Name BEVEL GEAR Type B.
Oper. No. 5BO
Operation Name Bore, rough hub, rough end of hub & shoulder
Dept. 11 Mach. Class 58 Mach. Name Jones & Lamson
Made by LP Approved by DV Date 10-21-25 Mat'l Cast Iron

No.	Procedure	Tools—Jigs, Etc.	Speed Setting	Speed Ft./Min.	Feed Setting	Feed In./Rev.	Base Time
	(Procedure continued)						
9-	FACE BACK OF GEAR	B- Same as #5	55	58	71	.014	.66
10-	Back turret & index, adv. headstock, adv. turret, change speed & throw in feed						.18
11-	ROUGH BORE FINISH HUB DIA.	C-3/8" Sq. Tools D-5/8" x 1¼" "	84	44 68	71 71	.014 .014	1.82
12-	Stop Mach., back turret & index, start mach., adv. turret & throw in feed						.18
13-	FINISH BORE	E- Kelly Cutter	84	44	71	.014	1.82
14-	Back & Index turret						.07
15-	CHAMFER BORE	Hand Scraper	84	44	Hand		.10
16-	Stop machine						.02
17-	Remove 2 blanks						.10
	Total Handling Time Per 2 Pcs.						1.50
	Machine Time						7.49
	Base Time						8.99
	Allowance 23%						2.07
	Std Time - 2 Pcs.						11.06
	Standard Time Each -						5.53

Figure 11

Obviously, in the second case, where the exact method of procedure is not known in advance, this method could not be used. Here, as Mr. Lowry says, "It is generally necessary to go on the floor and make an analytical motion study in order to determine the elements that are required for the operation." Having the standard data, it is merely necessary to fill in the standard allowed time for each element in the study. This, as he points out, results in a great saving of time and increases the uniformity and accuracy of the results.

It is hoped that the possibilities afforded by these applications of time study will be more universally appreciated, whether used for an exact predetermination of time or in the rougher form as a basis for scheduling or cost estimation, and that the predictions made by Frederick W. Taylor will become an accomplished fact. The result should be improved conditions for all concerned in industrial enterprises.

The Relations of Time Study and Motion Study

By **LILLIAN M. GILBRETH**
Gilbreth, Inc., Montclair, N. J.

THE AIM of both time study and motion study is to eliminate waste, to enable the worker to increase his production and his wages without increasing his effort, and the employer to provide the conditions necessary for this. Thus, motion study and time study are fundamentally complementary. There may be disputes as to relative importance and overlapping of activities, but the settling of these should furnish no serious problem.

Time study has been defined as a method of finding "how long it takes to do work"; motion study as a method of finding "the best way to do work," that is, how the work should be done. Each supplements the other. It would seem self-evident that one should discover *how* work is to be done before attempting to time it; also, if one has discovered how it should be done, that it should be necessary to find out *how long* it takes to do it in this way, in order to make the proposed method standard and compare it with older or newer methods.

If, then, we take time study and motion study in the broader sense of the terms, their relations must be co-operative, if either is to do good work. Each requires the other. If we take the two terms to signify two competing techniques in method study, we may come to some differences needing to be reconciled. Perhaps an outline of the technique of motion study, with which the writer is better acquainted, will help toward this.

Motion study starts always with a survey. This is useful in any type of problem, whether the work involves many people or few, is repetitive or not, and whatever the kind of activity involved. The first point is to find out some of the factors that enter into possibilities for saving money, time and effort. These all govern the amount of methods investigation that will be profitable. If the work is to be done by many people, if for only a short time; or even by only a few people many times, or if it contains elements of motions which are common to many jobs, then detailed motion study is warranted.

The preliminary survey records, in such detail as may seem advisable, the type of worker being used, the condition of the work place, surroundings, equipment and tools, and the method being used to do the work. The device used by motion study for this is the process chart, which visualizes the method and includes sketches of the work place and such notes on the workers' characteristics as seem useful. The process chart makes it possible for everyone interested in the study to participate in a group discussion, for it records and visualizes what is going on, and presents specific topics for consideration. Its study suggests operations which may be eliminated, and combinations or simplifications which may be made. It also assists in determining the amount of detailed investigation that each subdivision of the operation deserves. It does not record time, for time is not the determining factor in an efficient work process, though it is important and must be considered later.

If the activity studied is a short time one, if further study is not justified for any other reasons, or if the results of the charting are so satisfactory that no other study is thought necessary at the time, the derived method is timed in any way desired. So far this is, in all essentials, the method used by the "time study" group, though they may use some other device than the process chart, and always use the stop watch for getting the time.

At this point motion study uses the technique of micro-motion study to help find the best method for doing those parts of the activity which justify more refined study. A film is made, using either the large or the small film, which records the special fast moving clock with the activity in the picture. Thus the exact motion cycle, and elements of motions, are recorded with the time to a "wink," or .0005 of a minute.

From these films charts are made that place in comparable form the work and rest motions and the times of the various workers filmed. These simultaneous motion cycle charts present the data from which the one best available method is to be derived. They show the most efficient motion cycles of the most efficient workers—some fast, some lazy, some rhythmic, but all efficient workers. From the records on these charts are selected, after careful comparative study, the elements of motions that are judged best for performing the activity. The selection and combination of these elements into a proposed standard method is the difficult part of micro-motion study and calls for all the natural aptitude, training and experience of the person making it. It is also, however, the part of micro-motion study that gives the most rigid and worth while training in thinking in motion economy.

The selected motion-element units are combined into a proposed method which is then tested by the rules for motion economy and for developing skills and satisfactions. These rules, which had to do at first only with the application of findings from the field of engineering, that is, mechanics, physics, etc., are now being supplemented by others from the fields of physiology, psychology and psychiatry. The work in this field is just beginning. A group of graduate students in social economy at Bryn Mawr, co-operating with the motion study group, has contributed much this year to work in this field. We hope within a few years to make a progress report, outlining technique and results, that will be of service.

The "one best" method as finally derived and standardized is understood to be only useful so long as the given workers, work place and conditions are maintained. It is, like the usual standard of scientific management, not a formula to be prescribed undiscriminatingly for everyone, but a norm from which to calculate individual differences. Our skills and satisfactions studies are helping us to understand both the "one best person," given the "one best way," and also the individual differences which make modifications necessary.

The times of the elements of motions, which were recorded on the films and transferred to the simo chart, are essential in distributing the activities to the various parts of the body, and make it possible to check the proposed method with the method it superseded. The new method is almost always, but not necessarily, shorter. It is much more important that it contain a smaller number of "therbligs," or elements of motions, or that the activity be more equally divided and distributed among the different parts of the body, than that it take the shortest possible amount of time. Fatigue and the related skills and satisfactions are much more significant than time. The accurate times are available, however, for use when needed.

The results of the micro-motion study are incorporated in instruction sheets and standing orders and used as material for setting rates. Useful as this micro-motion study is as a device of motion study which makes it possible to get accurate data, it is still more useful in training the person who makes it *to think in terms of motion economy.* It is the rigid discipline of this method that makes it possible to get the most value out of such a preliminary motion study survey as was outlined at the beginning of this paper. Through the process of making a micro-motion analysis and synthesis, the person making the study, everyone being studied, and even everyone interested in or observing the study, get a certain amount of experience in methods of motion economy. This is the extensive contribution of micro-motion study just as the data gathered are the intensive contribution.

The uses of motion study are:

1. It assists in selection and placement.
2. It acts as both teaching and methods data.
3. It is a guide for invention.
4. It is a check on machine design, construction and operation.
5. It derives (a) the best available method, given the available workers, work place and tools, and (b) the best possible method, so far as available suggestions at the time can go.
6. It enables every member of the organization using it to have at his disposal a method of thinking in terms of motion economy and better work methods.

It is of course for time study to outline its own technique and to indicate to what extent motion study is used or could be serviceable. We feel that both the study of motions and the study of times are essential to method study or job analysis. Micro-motion study and stop watch time study are two ways of recording work methods and the time that they take. Each has its place. Motion study, as practiced by our group, uses the stop watch where it can do the work adequately. We believe, however, that the film data are more accurate, and more useful for teaching purposes, and therefore that the micro-motion method is advisable in many more cases than are generally recognized. The decreasing cost of films, cameras, etc., often makes the micro-motion record cheaper than the stop watch record. The simo charts and the synthesis work demand both time and effort. The cost is always predetermined, however, and an adequately trained motion study man makes his work pay immediately as well as ultimately.

Whether the films and other devices of motion study are used or not, its methods of studying work to eliminate waste activity are available to all. It would emphasize this most strongly, but would add that its chief claim to usefulness lies in the fact that it enables the user, through the refinements and devices, to take up more intelligently and with greater interest, all the problems of getting times and motions.

Standardization of Conditions and Analysis of Operations

By G. J. STEGEMERTEN
Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Introduction

AS YOU know, the time study man has been referred to as an engineer, an efficiency man, a rate setter, an estimator, a limit setter and an analyst. It seems to me that the most appropriate term for this discussion is "time study engineer." In the works which I am proud to represent, we do not tolerate the man who accepts conditions as they are, records several cycles of watch readings, arrives at a representative time value for each element of the job, and passes on to the man an allowance which means little or nothing.

On the other hand, we insist upon and instruct our men to analyze carefully each job with a view to making improvements in methods, tools, design and the like, before any watch readings are recorded. To be able to read a stop watch and make a record of such figures is probably the easiest and least important part of the time study. Far better is it to know what should or should not be observed, the proper sequence of elements, and the amount of skill and effort the man is applying to the job.

Analysis and standardization, therefore, play a very important part in time study work and, in the paper which follows, the term "time study engineer" should be construed to mean one who not only makes time studies for wage incentives, but in addition, one who subjects to thorough analysis every part of every job he studies with a view to eliminating the unnecessary and standardizing the necessary operations.

I have chosen to reverse the order of my assignment and to deal first with the "Analysis of Operations," following this by a discourse on the "Standardization of Conditions," since that seems to be the more logical sequence.

Analysis of Operations

In analyzing a job, many things will of necessity be taken into consideration. Not only will tools, materials and the method of procedure be scrutinized but attention will also be given the worker performing the job and the conditions under which he is obliged to work.

To make an intelligent analysis of a job requires that one be well versed in the practical knowledge peculiar to that particular job. The time study engineer must not only know the proper tools for performing a given operation but must be able to determine whether or not the workman is proficient in the use of such tools.

In addition to this practical knowledge, a thorough understanding of human nature and ability to judge effort and skill solely from the evidence at hand are essential, regardless of any opinion that might be entertained concerning the workman's honesty.

Before one can be expected to pass judgment on the proper way to perform a job it is necessary that he have a good idea of how the part is to be used. He must know why the operation is being performed and the function the part will fulfill in the finished product. Roughing cuts are sometimes as satisfactory as fine finishing cuts and grinding. Apparatus which is to be obscured from view in its installation need not be so pleasing to the eye as that which is to be constantly in full vision of passersby.

It is necessary to know when a part being machined is to have a running fit or a driving fit, an electric contact surface or a surface merely smoothed up for appearance. The effect that a close or a loose fit will have on the performance of the apparatus should be understood. In general, the reason for every detail operation being performed and its effect in the ultimate use and success of the product should be determined. Then it will be possible to make intelligent suggestions with the ends in view of improving the product, eliminating unnecessary operations, and facilitating necessary work.

After the purpose of the operation has been determined, the inspector should be consulted in order to ascertain the inspection requirements. The inspection requirements, too, should be based on a thorough knowledge of the purpose of the operation. It should be known whether a dimension should be held to within a few thousandths or whether a variation of one sixty-fourth of an inch is allowable. The time study engineer and inspector must work in close harmony in this respect in order that time allowances may apply closely to the work at hand.

Every possible effort should be put forth to eliminate abnormal conditions as concerns materials. If the physical properties of materials are not meeting specifications, the cause should be ascertained and an attempt made to bring about a correction. Excess material on castings over that necessary to insure the required finish should be eliminated at the foundry if practicable to do so. Excess material not only requires more time to machine without improving the finish of the product but it also results in a great waste. It is very common to see a machine hand removing one-half inch or more of material when it should not be necessary to remove more than one-quarter inch to make a perfect job. Fewer cuts would here be required and the amount of scrap would be greatly reduced.

In assembly work, specifications should be closely followed to avoid unnecessary filing and fitting. Shop practice should be made to conform with specifications or the latter should be revised to suit conditions.

Expense materials such as oil, cutting compounds and molding sand should be suited to the nature of the work. It is necessary to use a fine sand in making aluminum castings, but it would be wasteful to use this same sand for some brass alloys because of the additional venting that would be required. In general, anything in the material which has a tendency to cause unnecessary work should be determined and corrected before establishing standard allowances.

When a job is started it is necessary to perform some operations which will not occur after the first piece is finished. These are usually termed "set-up" operations. Getting time slips, drawings, instruction cards, material, tools, arranging the tools in the machine, setting stops by trial cuts and locating dial positions, arranging tools and equipment for a bench operation, and making templates are all considered as set-up operations. Whatever the nature of the work, there will always be a certain amount of preparation work required, and in most cases, the ease and the efficiency with which the work will be done depend largely on the preparatory work. This fact must be recognized and the set-up subjected to a thorough analysis keeping ever in mind the idea of improving and simplifying the operation with a resultant saving in time and improvement of quality. Any work which will be required to get the job started each time it is done should be considered as a set-up operation.

In shops where time study does not exist it is found that the output of operators on the same line of work varies greatly. Here each individual does his own work according to his own ideas and, in most cases, never stops to consider whether or not the method can be improved upon. It makes little difference to these operators how the job is performed so long as it meets certain established inspection requirements. In the event that several or all of these operations were studied, it would probably develop that, if the advantages of all methods were combined and followed as a standard, production would be greatly increased without increasing effort. A thorough analysis will often show that those operators turning out the greatest production are not expending so much energy as those turning out the lesser production. The former know that brain work is essential to systematic handwork and have developed a smooth method of procedure which may be applied to the less efficient operators by careful instruction.

Labor saving hand tools, such as socket and ratchet wrenches, air hammers, air chippers, and the like, should be used whenever a saving in time would result. In assembling brackets to frames in one of our assembly departments the substitution of Yankee socket wrenches for common hand socket wrenches cut the time required to perform this operation in half.

Cutting tools used on machines should be properly ground and should have the correct clearances and shapes. Machine tools and all driving equipment and belts should be in good repair. The time study engineer should determine whether or not the work is being done on the machine best suited to the job being studied. No job should be finished on a milling machine, lathe, or boring mill that could be worked to an advantage on a grinder or vice versa. In analyzing the tools used on a job, it is sometimes found that the operation could be segregated to an advantage, that is, part of it could be done on one machine and part on another with a resultant saving in the time required to complete the job.

Wherever the quantity warrants, special jigs and fixtures should be used, as they effect a great saving in time and assure more accurate and uniform work. Multiple jigs and fixtures, that is, those made to hold several pieces, should be applied whenever it would be an advantage to do so. Indexing and rotary fixtures should be used in machining operations wherever possible, as they very often make it possible to reduce the time for performing an operation to the time required to remove and place the part to be machined. Self-centering devices on lathe operations should be used where practicable. Often it will be found advantageous to secure two fixtures where it is necessary to remove the fixture to reload it. The operator can then load one while the cut is being made on the other.

The time study engineer should continually try to reduce time and labor by the elimination of elements of the operation through the application of specially designed fixtures. To give an example of what can be accomplished by the application of special fixtures, a job that was formerly ground on a plane surface grinder was held in a vise during the operation. It was suggested that a multiple fixture be made and that the job be done on a Blanchard grinder. Accordingly a fixture to hold twenty pieces was designed and made. The work was transferred to the Blanchard grinder and a saving of eighty per cent in time was made.

Bench operations should not be neglected even though they appear to be of a simple nature. Analysis may show that the location, design, and arrangement of the bench are not what they should be. The height must be right to avoid fatigue. In special cases the bench may be made to suit conditions.

Handling devices which may aid the performance of the operation should be utilized when, by so doing, the time will be reduced. Jib cranes are often essential near machines handling large, heavy parts. Gravity fed chutes, from which supplies may be quickly extracted, a given number at a time, may be utilized to speed up bench operations. Chutes fed by overhead conveyors save a molder much time in filling his flask with sand. The properly trained time study engineer will constantly seek to use devices which will either improve the quality of the product without increasing the cost or which will decrease the cost without detracting from the quality.

The manner in which the material is supplied and the finished product removed after the operation has been completed is an important consideration. Where the workman is obliged to go for the material himself he should be allowed time for it. Perhaps it will be found that so much time is required in this handling that it would pay to have a lower priced material handler attend to these duties and thus release the high grade operator for more appropriate work.

Material and part handling should be reduced to a minimum. The sequence of operations should be studied for the purpose of determining the best possible layout of equipment, selecting that arrangement which provides for the installation of conveyors between machines or work stations, if the nature of the work prevents efficient moving of material by hand. Gravity conveyors should be employed wherever possible due to the cheapness of installation and low upkeep common to this type of conveyor. Special trucks, racks and ingenious devices may be made to handle delicate parts with the least possible amount of damage.

Many jobs require the use of nuts, bolts, lock washers, rivets, and other miscellaneous parts that are commonly called indirect materials or supplies. The amount of time which the operator must spend in getting such materials from the storeroom and in placing them in convenient receptacles around his work station, must be considered with the view to later determination of a supply allowance.

A special allowance should be made for indirect operations such as oiling and cleaning machines, general maintenance of equipment and the supplying of so-called expense materials such as sand paper, solder paste, cutting compound, and the like.

The human element must be taken into account. It was formerly thought that the workman was not concerned about the conditions under which he labored to earn a livelihood for himself and his dependents as long as he received his wages. The fallacy of this is now generally recognized, and most employers know that money spent to provide good healthful conditions is an investment which pays dividends.

One of the most important requirements of a time study engineer is that, in his analysis of a job, he be able to determine the proper fatigue allowance for each element of an operation. Standard allowances, based on an extensive study of the strenuousness of the work, should be determined for the different classes of operations. It is quite evident that heavy filing is more fatiguing than the laying out of a part, and that forging requires the expenditure of more energy than most classes of assembly work.

An operator cannot be expected to work steadily all day without delays from some cause. Human requirements, minor breakdowns and other irregularities which cannot be foreseen will interfere, thus necessitating the determination of an allowance to add to all time values to care for such unavoidable delays. It would be unjust to penalize the workman for something over which he has no control.

Temperature is an important consideration. In many places, such as around furnaces or near solder pots, it is nearly impossible to maintain the ideal temperature. Fans or some other kind of forced draft may be used to advantage to keep the air circulating, but in most cases the temperature will be variable. An allowance for such conditions must be made when considering the effort an operator will be able to give throughout the day.

Ventilation should be adequate to provide sufficient fresh air at all times. In ordinary work places, such as machine shops or assembly rooms, it is usually easy to insure this through proper arrangement of windows, fans and ventilators. In many places, however, the matter of proper ventilation offers a serious problem. Acid fumes, dust, and the like must be removed by specially constructed suction devices. Paint shops and dip rooms often abound in unpleasant odors which, while not actually injurious, are irritating and may cause headaches. An operator cannot be expected to do his best work under such conditions, and if the conditions cannot be corrected extra allowances must be made.

Daylight is preferable to artificial light and should be utilized wherever possible. Eye strain due to poor light should always be guarded against. A man cannot turn out accurate work if he cannot read his scales and verniers with ease, nor can he work at his greatest speed if he is not able to see exactly what he is doing.

It is not possible to overestimate the importance of giving due consideration to all these factors.

Standardizing the Job

Analysis, as has been said, always precedes standardization. The former involves the determination of the best way to perform a job; standardization deals with associating like characteristics of operations and jobs and is much broader in application. During analysis, one particular operation is considered while, in standardization, operations as a class are considered and attempts made to standardize those which are similar.

The advantages of standardizing and specializing have been recognized in almost every industry. Few will try to belittle what has been accomplished by standardization in industrial plants where a single product is manufactured. Many, however, believe that this is the only type of plant to which the principles of standardization may be applied. It is true that a single product plant lends itself more readily to standardization than does the plant manufacturing a variety of products in small quantities. But standardization should not be thus restricted, for there is proportionately as much to be accomplished in the latter case as there is in the former.

Standardization first comes into play in the engineering department where the designs are made. Design engineers, like everyone else, wish to be original and want to create something. This tendency, while laudable in the field of research, must be somewhat suppressed in the field of minor design after the fundamental features to be incorporated in the product have been fully developed. This minor design involves the designing of various sizes, capacities, and the like, for a standard type of product. In designing several of these, the engineer is likely to make minor changes in each size part for no other reason than that he does not want anyone to believe him incapable of working out things for himself. He does not wish to appear to be copying some other engineer's work.

In manufacturing, by cutting down the number of designs emanating from the engineering department, standardization permits longer runs with fewer set-ups. Less study on the part of the workman and less clerical work are required since the number of drawings and the amount of manufacturing information is reduced. Familiarity with the drawings and specifications ultimately brings to any shop advantages of specialization.

Where materials are simplified into a few classes and sizes, the stores carried on hand will be greatly reduced. Part of the money tied up in raw materials will be released for more profitable purposes. Not only will the store rooms be smaller and the number of men needed to run them be fewer, but also there will more often be material on hand when it is needed. The delays which were formerly caused by the exhaustion of the store of some special, hard-to-obtain material by an unexpectedly large order will be minimized. This is true also of raw castings and supply material.

The effect of standardization on the worker is very marked. The workman will become familiar with his job more quickly if the job is more nearly the same from day to day. He works with the same materials constantly, and he soon learns to get the most out of his machine by using the safe maximum feeds and speeds. When a standard method of procedure has been established and is followed, the operator becomes highly skilled in using this procedure through constant repetition of the same motions. He becomes an expert and, as an expert, will produce more work of a higher quality with less waste, breakage, and lost time than a man working under non-standard conditions.

The method of procedure should be standardized for all lines of work. The elements of all operations should compare favorably and should follow the same line of sequence. In the case of machine work on turret lathes, the same tool arrangement should be made and speeds and feeds should be made to conform. Here the advantages of all possible methods will have been selected and accepted as the standard method of procedure to be followed. Material, tools, and equipment will allow of slight variation and the closest approach to ideal conditions will here be found. This of course is highly desirable and an effort should be put forth in any industrial concern to follow this example.

Supervision is greatly simplified where methods, equipment and design are standard. One foreman can handle more men and will not have to bother with details as he would were he constantly studying new jobs and instructing new workers. Not having this to do, he is able to concentrate on the established work of his department and can devote his time to planning better and cheaper methods for doing it. He is freer to study his men and place them on the jobs for which they are best fitted.

Paper routine is reduced to a large extent by standardization. Record files are smaller, cost systems simpler, and timekeeping easier. The non-productive clerical force is smaller where all work is very nearly standard.

All of these things have the tendency to reduce costs and overhead expense. Non-productive set-ups are minimized, thus allowing the same number of machines to turn out more product or a lesser number of machines to turn out the same product. Lost time, unproductive effort and idle machinery are greatly reduced. A better quality of product is turned out at a lower cost of manufacture, and this product is placed in a more favorable position in the field of competition.

In factories where a single product is manufactured, there will be one or more machines used for a single operation. These will have a special set-up, special tools, and equipment made for a single purpose. There will be as many of these set-ups as there are operations. When a time study engineer has a condition of this kind to deal with, his work is comparatively easy; where the work is more of a jobbing nature, it is a different proposition. In the first case, when the time value is established for an operation, the whole group of machines employed on that operation is taken care of, until some change is made, and it is only a matter of time before time values covering every operation performed in manufacturing the product are set. In the second case, sufficient data must first be collected to cover every condition that may arise, and then this data must be applied to every new job that comes along. The time study engineer should, in the latter instance, try to get his conditions standardized as much as possible. He should have as his ideal the shop that is manufacturing a single product even though he knows that he can never reach that goal. He should realize that, just because the product is varied, it is not necessary to have the same number of variations in tools and equipment. At the same time, he should also keep in mind the desirability of special labor saving conveniences for individual jobs and machines.

There is usually a certain make of machine that has advantages over all other makes of similar machines for doing a certain job. This machine may or may not be available, but there will be among those that are available, one type that will be better than the others. It is not uncommon to see three or four different makes of machines used on the same class of work, and sometimes it is impracticable to control the flow of individual jobs so that they will be performed on the same machine every time they repeat. This condition makes it necessary to determine a time allowance for each machine on which the job may be done, even though this may not be entirely satisfactory.

A good example of this occurred in a machine shop where three radial drill presses were used. On two of these machines the speed in revolutions per minute ranged from seventeen to 240 in seven steps and the feed per revolution from 0.0066 to 0.011 of an inch. On the other machine, the speed in revolutions per minute ranged from forty-four to 474 in twenty-two steps and the feed per revolution from 0.007 to 0.031 of an inch. The advantage that the third machine had over the other two is obvious, and since it was impossible to control the flow of work to the individual machines of the group, the difficulties encountered in establishing time values may be appreciated. It was found that the third machine did approximately thirty-five per cent more work than the other two, and the problem was solved in this case by replacing the first two machines with one of the third type. The two that were taken out were used on other work. Of course, it is not always practicable to do this as the resultant saving may not justify the expense.

All equipment must first be suitable for the work to be done by it. In many cases, it will be found that several different types or makes will turn out the same quality of finished product. The time required to attain this standard of quality may vary widely on the different machines. In purchasing new equipment it is well to select the new in conformity to that type which permits the meeting of inspection requirements in the least possible amount of time. It is sometimes poor business policy, however, to buy all machines from one concern, and as a result, ideal conditions in this respect are seldom realized. This difficulty has been greatly offset of late in the case of machines where many of the characteristics have been standardized and the parts are pretty generally interchangeable.

Conclusion

In conclusion it might be said that analysis, as here applied, deals with the resolving of an operation into its elements for the purpose of discriminating between necessities and non-essentials. By a systematic study of these elements the one best method of performing the operation will suggest itself. This method should then be adopted as a standard to which all similar operations should be made to conform.

The foregoing principles have been closely followed by the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Company for quite some time with very satisfactory results.

Discussion

Howard G. Benedict.[*] The admonition of Frederick W. Taylor regarding the need of standardizing conditions and operations is just as applicable today as when it was presented twenty-five years ago in his paper on "Shop Management" before the American Society of Mechanical Engineers. In all of his work Mr. Taylor emphasized that "The adoption and maintenance of standard tools, fixtures and appliances, down to the smallest item throughout the works and office, as well as the adoption of standard methods of doing all operations which are repeated, is a matter of importance, so that under similar conditions the same appliances and methods shall be used throughout the plant. This is an absolutely necessary preliminary to success in assigning daily tasks which are fair and which can be carried out with certainty. . . . Neglecting to take the time and trouble to thoroughly standardize all of such methods and details is one of the chief causes for setbacks and failure in introducing this system."

When we consider the tremendous strides that have been made in the twenty-five years since Taylor wrote this, and the still further progress that is being made day by day in mechanical processing and in the continuous flow of product through the plants, not only in the automotive but in the countless other industries, it is even more important that we heed this warning today and be sure that we standardize conditions and methods of operation in our departments before attempting to establish tasks and set rates for the accomplishment of these tasks. In the studying of conditions we may use the stop watch or the motion picture machine to determine relative values and detect the extent of present losses, but we should not use them for the setting of tasks until the conditions have been standardized.

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Therefore before we even approach the setting of tasks we must make a study of our machine equipment in a given department, and analyze the machine arrangement. Many a straight line flow of product is possible today where arrangement by classes of machine tools was formerly used. And in many cases, departmentalization by divisions of the product can now be more advantageously used than the previous departmentalization by classes of machine tools. Conveyors and other mechanical devices for handling the work from one operation to another can very frequently be adopted to advantage, both to reduce the cost of handling and to speed up the flow of the product toward and through its final operations.

An analysis and standardization of the speeds and feeds on the machine tools in a department very often yield a tremendous increase in output and also make possible greater flexibility of manufacture.

Probably everyone here takes standardized tools for granted, but there are still many managers, superintendents and foremen who hedge when it comes to adopting standard tools for given operations. If we are to get results in these days of severe competition, no manager can afford to let the operator decide what kind of a tool, the particular cutting edge or the heat treatment that is to be used on a job.

It is necessary to make very searching studies of tool requirements and, on the basis of these, to adopt standard shapes, clearances, cutting angles, heat treatments, etc., for our cutting tools. We must also make provision for the proper inspection, maintenance, sharpening and conditioning of these tools in a central tool room, well in advance of their being issued to operators. This also develops the advantage of adequate provision for tool storage facilities and provision for rapidly checking tools out of, and back into, the central tool storage, with no delay whatever on the part of the operator.

It is useless for us to take time studies and set tasks if, when we need an operation done, either the operator, the materials, the tools or the machine are not available or in proper condition for such a job. Therefore, while the preliminary standardization of machine equipment, tools and operations is going on, it is extremely important that analysis be made of the *control of production* and that proper provision also be made for the graphic control of all work going through the department. This calls for the detailed planning of all work well in advance and for the advance assignment of jobs to workers and machines, with provision to insure absolutely that tools and materials will be at the work stations at the required time, in readiness for the work to be done.

This makes possible standard and uniform conditions, so that when tasks are set from the time studies that follow standardization, the times allowed will not include superfluous time which should not be a part of the producing job, and will force the proper preparation of tools, materials, machines, etc., on all time studied jobs continuously. One of the most salutary effects of the proper use of time study, with its preceding standardization, is that it forces management to continually do its part in adequately *serving the worker,* by providing the proper conditions surrounding the actual producing job.

There are many incidental gains from this same study of production conditions and the institution of proper methods of production control. In one case recently we found in a department confined to the making of a single part in three sizes, each size having about fifty or sixty operations, that the average number of working days taken for the lots to pass through the department was 152, while actual processing occurred on only thirty-eight days. 114 days, or seventy-five per cent of the total time in the department, was idle time between operations. Needless to say, the inauguration of proper graphic production control not only provided standard conditions, so that the workers were enabled to do the jobs in less time at higher wages, but also eliminated practically all of this uncalled for "standstill" time.

One of the things to study and standardize before taking time studies is the proper type of operators for the different jobs to be done. Where no classifications of operations and workers have been made, it has been found that there is an amazing number of misfits in the work in a department—square pegs forced into round holes. Oftentimes the work that a nimble fingered girl can do to the best advantage is left to a boy or man, who is better fitted for heavier work. I have found that very fine work, perhaps requiring a magnifying eye glass, as in fine watch work, is often assigned to a worker whose eyesight is not as good as it should be, or who is not adept or careful with very fine work or small delicate tools. Therefore, one of the early studies should be of the abilities and limitations of the workers within a department, and of the minute requirements demanded of the workers for the various operations done in that department.

This will result in a definite classification of the operations to be performed and in a minute classification of the abilities and limitations of the workers in that department. All new and changed operations should undergo this same analysis and classification, and all new or transferred workers should be thus studied and classified. This has the additional benefit of clearly pointing out the possibly otherwise obscured weaknesses of some workers. It is then possible to give them specialized training so that they may advance in the direction where they have the greatest need or the most promising inclinations, and where there may be the smallest supply of workers.

With this classification of workers and operations, it is much more possible to plan in advance, and assign workers to the proper tasks, than when the foreman was allowed to put a worker on a job because it happened to be the nearest one at hand when the operator unexpectedly came up to ask for his next job.

This classification enables us in our time study to specify the type of worker best fitted for an operation and to be sure that the operator thus adapted to it *will* be assigned to the job every time it is put through the department. More expert work, and therefore, better quality in shorter time result.

In one case recently studied, we found that on thirty lots of the same part put through a given operation, twenty different workers had been assigned to the operation, while only five workers were particularly adapted by experience and aptness to the performance of this operation. Following the classification of workers and operations and the time study of the job, a limitation of the work to these five workers, and in a majority of the lots to but three of the workers, resulted in each of these becoming much more expert. The incentive also reduced the time of the operation and greatly improved the quality of the work that it was possible to turn out.

Among the factors to be studied and standardized before setting tasks, we must not overlook the quality standards or fail to make adequate provision for the functioning of these.

We must be sure that the operator has a detailed instruction sheet showing him (graphically where possible) just how the operation must be performed, and then we must have the machinery in operation to insure that we are actually getting the work done as specified. This involves not only a proper inspection of the work after the operation is done, but an adequate "preventive inspection" and check-up of the operation when it is started, and while it is in process in some cases.

Many of these preliminary steps can be going on while the actual time study of the operations is being done by others in the organization. However, extreme care should be used not to set and put into effect rates which are based upon the existence of standardized conditions before these standards are fully effective. We must also guard against the setting of rates on jobs, the conditions of which are not standardized, unless it is particularly specified that the rates set are merely temporary rates and that the jobs will be restudied and new rates set when standardized conditions become effective.

Elliott Dunlap Smith.[7] In the discussion of time study and rate setting much has rightly been said of the importance of securing the understanding and co-operation of the employes. Nothing has been said of securing the co-operation of the management. The co-operation of the management, especially of the foreman and other executives in direct contact with the rate setting problems on the working floor, is, however, of critical importance, for it is these executives who determine the conditions upon which the accurate setting of the rate and the successful working out of the rate both largely depend. It is true that support from the higher management is important; but this is rarely adequate unless it is supplemented by support from below. To be steadied from above is always helpful; to be suspended only from above is usually embarrassing. For rate setting men to secure intelligent support of executives on the working floor, it is important to bear the following points in mind:

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[7] Dennison Manufacturing Company, Framingham, Mass. Mr. Smith spoke extemporaneously and the above is only a digest of his remarks.

1. Do not overstate the results to be obtained. Enthusiasm is only valuable insofar as it is justified by the facts; for disillusionment always is costly.

2. Do not know it all. The executives who spend their time on the working floor have usually learned something that cannot be discovered by studies or figures. They like to feel that their knowledge is considered.

3. Never, if it can be helped, put the foreman in the wrong. Usually it can be helped if one tries hard enough. For a staff man to make a foreman feel that his success is at the foreman's expense is to provoke conflict; to make the foreman feel that the staff man's success will contribute to his, is to invite support.

4. Put full confidence in the foreman. Unless a staff man lets the foreman know his plans, his problems, his methods and his aims, he cannot expect in return either confidence or understanding co-operation.

5. Work with the foreman in getting results. If the foreman has had a share in the work throughout, he will have that thorough understanding of it which can only come from having gone through the experience of developing it. Besides, he will have a sense of proprietorship in the work that will carry his co-operation past the inevitable discouragements. Last, but not least, a foreman usually has much of value to contribute to any program of rate study.

Only when the staff men thus work from the start with the men directly in charge of the employes, sharing with them in knowledge, in contriving and in doing, can the fullest co-operation and the best and most enduring results be obtained.

Selection of Workers for Observation

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Introduction

PERHAPS it should be stated at the start that operations usually are, and should be, analyzed and studied in the spirit of fairness to both the worker and the management. Without such an attitude the analyst cannot hope to get satisfactory and lasting results.

A standard of performance is set in this same spirit and the investigator seeking to obtain data which will yield the most desirable results is required to select the subjects best suited to the particular technique which he is to employ. Consequently the selection of workers for observation is but a means to that end. The time study technique calls for the study of workers whose performance will result in a standard which is attainable by the "average" worker, while the motion study technique calls for the study of workers whose method and performance will contribute most toward the establishment of the best method with the purpose of transferring it to others. Allowance should, of course, always be made for beginners.

Selection of Workers for Time Studies

Investigators employing the stop watch time study technique differ in their practice of selecting workers for observation. Some observe the worker whose performance represents that of the average of the department; others base their standard on the average performance of a group of best workers; a few study the best workers available; while most of them select the "first class men" as subjects for the study. The writer wishes to examine each of these selections in the light of the reasons for which they are made, of the results obtained, and of their value to management.

The Average Man

Much has been said and written concerning the "average man" but very little is known as to just what he is. The remark has very often been made that "there is no such animal." Unfortunately there is no unit of measurement available today upon which we may base an accurate determination of the grades of workers. The multitude of variables which enter into the problem make the establishment of such units difficult. Thus far, the term average can only be used to mean arithmetic average. One cannot speak of average physical and intellectual qualities, unless they can be related to some basic unit. When the average worker is selected, the only thing we can be sure of is that his rate of output represents the arithmetic average of the rate of output of all workers, from the best to the poorest, engaged in the same work. The standards for other qualities desired in the subject are assumed, and vary largely with the judgment and opinion of the analyst and others aiding in the selection. The results obtained from this procedure cannot satisfactorily serve the purpose for which they are obtained.

Another equally bad practice is to base the standard on the average results from the studies of a number of workers ranging from the slowest to the fastest. These questions then arise: Why is the former worker the slowest and the latter the fastest? What should their performance be? There is little doubt that a standard based on information gotten from the study of poor workers contributes very little, if any, toward raising the performance level of the department as a whole. As Colonel Hathaway puts it, "It has the effect of sanctioning if not encouraging mediocrity."[8] In discussing this practice he further states that "The principal error lies in attempting to base the standard on the production of the average worker. I should consider figures arrived at as a result of three or four studies of work done by ten workers (supposedly including a range from the fastest to the slowest) as not being worth the time and trouble taken to accumulate them. Such studies cannot help but be inaccurate individually and their faults are increased in proportion to their number. This practice is based upon, and is calculated to perpetuate, an all too prevalent error to the effect that there is a wide and permanent difference in skill and productive ability of different workers on the same kind of work; or in other words, that some workers are predestined to be and remain first class, some fair to middling and others poor. Such a doctrine is revolting and I believe unsound socially and economically."[9]

The stability of a standard established by these procedures is questionable for "it is only time study data based on reasonably first class performance that abides."[10]

The "First Class" or "Skilled" Worker

The stop watch time study technique calls for the "first class" or "skilled" worker as the best subject for the study. Here again we are faced with the task of defining, or rather explaining, the meaning of words which have been chosen to represent the productive ability of individuals. Our meager knowledge of the true nature of skill will not permit us to offer an explanation of any scientific value and we can only consider them on a basis of comparison of assumed grades. However, by limiting the study to this class of worker many factors which rendered inaccurate the results from the study of mediocre performance are removed. It is possible then to judge more accurately the usefulness of the data accumulated. The good workers generally use methods of less fatigue and have automaticity in them. Consequently they can work more steadily and with less variation in rate of production—making them more dependable and desirable subjects. Colonel Hathaway was taught by Taylor to understand the term "first class" as "a steady, intelligent and conscientious worker, skilled in the trade, who produced good work and whose performance might under proper conditions and instruction reasonably be expected to be attained by anyone physically, intellectually and temperamentally suited to the work."[11] A standard based on first class performance would be unfair to lower class workers, unless allowances for variations in skill were made in order to place it within their reach. There are several ways in which this may be done, but time and space do not permit the discussion of each. However, in consideration of the differences in productive ability, the writer takes this opportunity to emphasize what in his opinion should be the chief purpose of analyzing any productive activity—that of elevating the performance of the poor workers to that of the best. Taylor in summarizing what should be the aim of management in all plants made the following statement in support of his "high wages and low labor cost" argument: "Each workman should be called upon to turn out the maximum work which a first rate man of his class can do and thrive under."[12] In this, Taylor makes clear that progress in management can and should be made by removing, as far as possible, the differences in productive ability of workers.

The Average of the Best Group of Workers Available

The subjects chosen for time studies under these conditions "must be adapted to a degree representative of the average of the best group of workers available"[13] and the standard based upon the average results obtained.

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[8] "A Report on the Production Standards Situation in the Ladies Garment Industry of Cleveland," August, 1925, p. V.

[9] Ibid, pp. IV-V.

[10] Morris L. Cooke, "Morale as a Factor in Time Study Technique," *Bulletin of the Taylor Society*, Vol. XII, No. 2, April, 1927.

[11] "Cleveland Report," op. cit., pp. VI-VII.

[12] Frederick W. Taylor, "Shop Management," p. 28.

The best worker available is not always studied because of the difficulties encountered with the stop watch technique in recording the time and method accurately enough to permit the transference of his skill to other workers. Another important reason why this person, if highly skilled, is sometimes not selected is because of the fear that the workers of a lower degree of skill, not understanding the methods of grading and adjustment used by the analyst to arrive at a fair standard, will suspect that a standard beyond their reach has been set.

Selection of Workers for Motion Studies

The workers studied by the investigator employing the motion study technique in which the late Major Frank B. Gilbreth pioneered, are selected largely on the basis of the contribution they can make toward the establishment of the best method. Usually much of the desired data is obtained from the study of the best available. By best available the worker who produces most is not necessarily meant, but the one whose method shows the greatest productivity possible, although he may not exert enough effort to realize its possibilities. In other words, the production record does not always indicate the best workers from the point of view of the methods employed by them. Invariably, however, the best workers, as indicated by their records, *do* have good methods and it is usually desirable to study them. Workers whose methods for any part of a cycle appear to be less fatiguing are also selected for the same study. The best workers available should be selected for the following reasons:

1. That they invariably employ methods of least fatigue.
2. That they usually have the highest degree of automaticity, thus making possible the analysis of a higher order of skill.
3. That the motion study technique, making use of the motion picture film and clock, permits a minute analysis of the method and performance.
4. That the technique permits a more detailed description of the established method (that is, in elements of motion) and shortens the learning period.
5. That the composite best method can be more easily transferred, making a higher performance standard attainable by all normal workers.

It may be well to state at this time that, in case of group work and if more than one group is engaged in the same kind of work, it is usually best to consider the part played by each worker in the group (assuming that each worker performs a different suboperation) and to study that particular part of each complete operation, selecting the best subject for it regardless of the group he is connected with.

Aside from the qualities already mentioned the worker selected for observation, regardless of the technique employed by the observer, should preferably be one with ability to learn and demonstrate new methods; one who is not disliked by his fellow workers and who will serve as nearly as possible as a co-investigator.

It is the opinion of the writer that the analysis of the performance of the best workers available, from the standpoint of method and economy of effort, and the transference of their combined skill contribute most toward elevating the performance standard of the department as a whole, and this, of course, is desirable from the point of view of lower cost and higher wages. We have both the intellectual and physical equipment to increase the effectiveness of our productive efforts and should make the most of our opportunity to practice, and benefit therefrom, the three regulative principles of industrial management ably stated by Church and Alford[14] as, "the systematic use of experience"; "the economic control of effort" and "the promotion of personal effectiveness." The greatest progress can be made by utilizing, to the best advantage, the facts derived from the study of leaders in their respective activities, whether these activities are carried on in the office or in the shop; in the store, or in the bank.

The Number of Workers to be Observed

By STEPHEN B. SPONDER
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IN THE development of time study technique, considerable stress is laid on the importance of the correct use of motions and of arriving at equitable operation times. Each is an integral part of the scheme of scientific management in the introduction of which Dr. Taylor was the guiding genius. In developing a time study technique much time and effort can be saved if important preliminary details are given the proper consideration. Praiseworthy books have been written which emphasize this point but there is yet much to be done along this line. This paper aims to do its bit by bringing out certain points for your consideration and discussion.

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[13] Sanford E. Thompson, "Smoothing the Wrinkles from Management—Time Study the Tool," *Bulletin of the Taylor Society,* Vol. XIII, No. 2, April, 1928.

[14] *American Machinist,* Vol. 36, p. 857.

In analyzing the subject of the number of workers to be observed when making a time study, it is apparent that several factors are involved.

The factors which will be discussed in this paper are general in character and applicable to practically all industrial operations. Naturally, the time study engineer will discover peculiar conditions surrounding some jobs which involve certain factors that are not universal in application. While they may be important in particular cases, they are disregarded here because of their limited application.

These general factors are: (1) the economic importance of the operation, (2) the nature of the operation, (3) the workers' efficiency, (4) the personnel, (5) the physical conditions affecting the work, and (6) the company policy.

While these factors are general, abnormal conditions may place one factor in a position of such importance that the others may be nearly obscured. Such a condition should not, however, influence the engineer to overlook the other factors.

If the time study engineer appreciates these general factors, and considers them thorougly, any specific condition requiring his attention will automatically be discovered.

An elaboration of each of these factors follows:

1. *The Economic Importance of an Operation.* The total amount of money invested in material and time, and the overhead expense made necessary by the job, should be of major importance in deciding how extensive the observations should be.

A minor operation from the economic point of view should receive minor consideration from the time study engineer if he is to prove an asset to his company. Thus the economic value of the job immediately limits the engineer in the number of workers he selects for observation.

2. *The Nature of the Operation.* Under this heading both variations in product and variations in the conditions affecting the time and motions on a job are important. A product of varied character must necessarily require extensive time study research, while in the case of a product of standard or constant character, the determination of standards of time is not so difficult.

All operations may be divided into two general classes, constant and variable. It follows that, for operations requiring only simple basic motions, the time may be so unvarying as to be constant. In these cases experience will enable the time study engineer to arrive at an equitable standard from his observation of nearly any experienced operator. Therefore, it is not necessary to observe more than one experienced worker.

When many operations of a constant nature are being performed, or are expected to be performed in the future, the time study engineer will naturally derive and establish fundamental base times. When these fundamental times are established it is not necessary to make any observations except for purposes of checking.

When the job is of a variable nature, the motions employed may be so complex as to preclude a positive analysis of the operation elements. Under these conditions, it will probably be necessary to observe and compare each element of the operation as performed by various experienced workers, in order to arrive at an equitable time standard for the cycle.

3. *Worker's Efficiency.* The importance which this factor will have in determining the number of workers to study will depend in a large measure upon the time study technique employed. When the policy is to establish standards based on the performance of the average worker, with small allowances, the performance of a few operators may be satisfactory. When it is the policy to establish time standards based on the performance of an expert worker, with high allowances to bring his performance within the range of the average operator, his performance alone may be satisfactory. When he is not available, it may be necessary to analyze and compare each element of the cycle as performed by the various average workers.

4. *Personnel.* The morale, type, temperament, intelligence and the trade knowledge possessed by a group of workers often influences the number of workers to be observed. Naturally the desirable type of worker to observe is open minded, co-

operative and industrious. These qualities, however, are not possessed by all workers, and the lack of any or all of them may make it necessary to observe more than one man to arrive at proper standards. It may also be necessary for psychological reasons to observe all the workers engaged on an operation in order to leave the impression that the standard is being established from the average performance of the group. Some workers become very nervous when under observation. This may make it necessary to observe other workers in order to accustom the nervous one to the idea of being observed. Where intelligence and the possession of trade knowledge are prime considerations, it is an advantage to study those workers who possess that knowledge to a high degree.

5. *Physical Conditions Affecting the Work.* This factor merits consideration for the reason that, if conditions are very abnormal, it is necessary to consider the reaction of the workers to these conditions. Abnormal conditions which cannot be corrected or modified are usually compensated for in the allowances added to the base time. It may often be necessary to study the effect of these corrections by observing all of the workers available.

6. *Company Policy.* Unfortunately the officers of some companies insist upon directing the details of time study procedure. This insistence on their part may mean, among other things, that the number of workers to be observed is fixed in all cases. Where this unfortunate condition exists, the time study observer will be required to exercise tact in order to satisfy his employers and at the same time conduct his work in accordance with his better judgment.

Let us now consider the application of these factors by citing cases where each particular factor influences the number of workers to be observed.

The following case points very clearly to the influence of the third factor, the workers' efficiency, on the number of workers to observe.

Ten highly skilled leather workers were engaged in assembling football helmets. The fact that ten workers were engaged upon this operation is sufficient proof of its economic value to the company.

All the other factors except the workers' efficiency were normal. An idea of their efficiency may be gained from the fact that the workers were from thirty to sixty per cent efficient, by comparison with the final standards established. An average, to say nothing of an expert, operator was not available. It was necessary to analyze each motion or set of motions, establish the time for each and incorportate this analysis into the performance of one operator. It can clearly be seen that recording the times taken by ten such operators would not assist the time study engineer in establishing an equitable base time.

It was necessary to observe and to teach one individual operator, using the best motions and the most efficient times of the ten workers.

In the above case, because of the importance of the workers' efficiency factor, it was necessary to observe more than one worker.

The next case deals with the operation of drawing copper wire. This is the first operation in the manufacture of finer sizes of wire and copper wire products.

The production schedule of the entire company is dependent on the smooth running of this operation. Its importance is, therefore, evident.

Copper wire varies sufficiently in its raw state to warrant more than usual care in fixing time standards. The variation in product necessarily results in variation in the elemental times. Thus, in determining standard times, the elements of more than one operator on this operation are analyzed and a net time arrived at by comparing these elemental times.

It was found that some of the elements that made this job variable were broken wire, machine breakdowns, and die trouble. It was very difficult for the operator to control any of these elements.

In this case the average worker was studied in establishing standards of performance. This policy fitted in naturally with the nature of this operation, which was such that the time for performance depended largely on elements beyond the control of the worker.

Another illustration, a time study of four operators, shows the actual delay factor during a period of 480 minutes continuous time. We shall consider these operators in order of efficiency, that is, first, expert; second, good; third, fair and fourth, poor.

The study for each shows the following percentages of delay: expert, twenty-two per cent; good, nineteen per cent; fair, twenty-nine per cent, and poor, twenty-seven per cent. These delay percentages were the result of normal and abnormal delays. The normal delays disclosed the true efficiency of the workers: expert, ten per cent; good, thirteen per cent; fair, sixteen per cent, and poor, twenty per cent. The irregular or abnormal delays were: expert, twelve per cent; good, six per cent; fair, thirteen per cent, and poor, seven per cent. Thus abnormal conditions really made it necessary to observe the four workers.

The next case deals with an operation on which it was necessary to observe only one operator. The operation is that of milling teeth in a steel comb to be ultimately used in a dog clipping machine. The operation consists of cutting teeth through about forty small steel plates at one sitting. It is an ordinary operation that can be performed by almost any experienced mill hand. The extent to which this operation is affected by the factors previously listed is not as great as in the last illustration. This operation is important only as to quality. In relation to the shop as a whole it has little importance. Only a few operators were engaged on this operation, which was not variable in nature. The overall dimensions were of a standard size, which eliminated the trouble arising out of differences in size. An efficient fixture also further reduced the possibility of variation.

Thus it was possible to determine standard times by analyzing the elements in the study of a single operation. These elements were: (1) pick up and insert forty pieces in fixtures; (2) tighten fixture; (3) move table and start cut; (4) cut teeth; (5) move table back; (6) loosen fixture; (7) remove finished piece and place in box.

The above elements are of a type easily analyzed and evaluated.

The efficiency of the operator was considered, and it was decided that it was sufficient to observe a skilled operator.

The skilled man was selected rather than the average because allowance could be made in the computation of time to take care of operators of varying degrees of skill working on the same operation. Also, the skilled man was better for observation because his motions were uniform and his work steady. The erratic work of the less skilled operator brings in all sorts of variables that have to be cut out in the final computations.

The skilled worker in this case possessed sufficient trade knowledge and his personal qualities, such as temperament and willingness to co-operate, made him a very desirable man to observe. It was, therefore, not necessary because of the personnel factor to observe more than one worker.

The physical conditions affecting this job, such as fumes, light, air, tendency to fatigue, etc., were not such as to make a study of various operators necessary. These conditions were normal and allowances were determined from a study of general conditions in the shop.

The company policy was such as to allow the time study engineer to use his best judgment regarding the "number of workers to be observed," which in this case was one.

Many other illustrations could be found to show how the number of workers to be observed should be determined. There is no doubt, however, that each case is affected by the preceding factors. It is my opinion that empirical data cannot serve as a true guide in deciding the number of workers to be observed.

This paper has attempted to point out that the time study engineer should develop a point of view, or a philosophy, if you will. I have attempted to point out that a definite method of reasoning, the basis of any scientific analysis, is involved.

In solving any problem which may confront him, the time study engineer must first decide what factors are involved, determine their cumulative influence in the situation and overcome the opposition which each factor presents. When the factors described in this paper are understood and their effects realized a logical solution of difficult problems is insured.

Methods of Observations

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THE inexperienced time study man usually considers that the taking of stop watch readings on an operation is the first, and often the only, step. There should be no haste to get stop watch readings on paper. The operation should be timed only after a job analysis has been made and methods and equipment standardized. This preparatory period is helpful to the time study man in establishing contact with the foreman and the workmen. It enables him to get acquainted with the men and them to become accustomed to seeing him around.

The preliminary job analysis enables the observer to determine (1) if the job is ready to be studied, (2) what to time, (3) data as to machine speeds, specifications, etc., and (4) the type of study necessary.

The job is ready to be studied only when the best available methods and equipment are in use. If their introduction changes the sequence of elements or the way in which the job is done, a sufficient time should be allowed for the workmen to learn the new method.

Money can be, and is, wasted every day because time study work is not planned. It is important to decide what must be studied to bring out the salient facts. On one job which called for practically a year's time study work, the products were carefully compared as to parts and specifications. Decision was made as to what products were to be studied and these studies scheduled weeks in advance.

The nature of the operation determines how many studies must be taken. In the elementary time study all elements are classed as either constant or variable. A constant element is one where the elapsed time is the same regardless of the part, product or order being worked on. In other words, whenever the same element occurs one standard time is used. The more variable elements—those where the time varies according to the size, shape, area or weight of the part—the more studies are needed to ascertain the effect of the variable factor on the time.

Observations can be classified under two types: (1) elementary time studies and (2) overall time studies or production studies. Each serves its purpose.

Time Study Tools

The chief tool of the observer is the stop watch. There are many types on the market. The experienced observer uses a decimal dial watch, free from all trick attachments and dial designs. The dial may be graduated into hundredths of an hour or hundredths of a minute. We prefer the latter. Each has its advocates. Some use a watch graduated into sixty seconds. Hundredths of a minute are the simplest to work with.

It is preferable to have a printed form on which to record stop watch readings and other data. There is little uniformity of design in time study sheets. They consist, in general, of two types. The first type was designed by Mr. Sanford E. Thompson. It is an eight and one-half by eleven inch sheet printed on one side. Over 250 readings can be recorded on one sheet. It is the most satisfactory for all around general use. The second type was designed primarily for use in machine shops. Usually it has one column for the elements, which are listed once in order of sequence. There are five, ten or twenty columns for stop watch readings, allowing ten readings for each element on one sheet. A board is necessary to hold the watch and sheet.

Taking the Study

In taking the elementary time study there are two methods of manipulating the watch: (1) continuous readings, and (2) individual readings.

In the former the watch runs continuously throughout the study and all lost time is accounted for. With the individual or "snap back" readings, the hand is snapped back to zero at the end of each element. Although this saves subtracting the continuous readings to get elapsed time, the continuous method is preferable. It is easier and more accurate than snapping back and allows for an overall check against a clock on total elapsed time.

At this point we are ready to begin our observations. The starting time of the study and the stopping time are recorded from a regular watch or clock. All necessary explanatory notes as to workman, clock number, tools, date of study, sketches, descriptions, must be entered on the sheets.

Where the type of time study sheet requires it, the elements must be symbolized. They can be given arbitrary letters of the alphabet in order of sequence or they can be given mnemonic letters such as "RR" for "remove roll." The latter is easier and better, since it is difficult to remember "remove roll" was "h," for example, under the first method.

Taking the study calls for accuracy, quickness and alertness on the part of the observer. To note and record stop watch readings of .02, .05, .10, .25 of a minute, steadily for an hour, two hours or even longer requires a technique of its own. The cycle may be broken by an unavoidable delay, an element performed out of sequence. It is always up to the observer to get an accurate study, under any circumstances.

The elements into which the operation has been analyzed should have clear cut starting and stopping points. They should be of not less than .02 or .03 minutes' duration nor more than 1.00 minute, unless the element involves "machine time" only. This enables the observer to judge the fairness of the elapsed time in setting standards.

Other than to point out that the time study is an original record and should be made with care and neatness, the steps in recording the readings are too obvious to call for any remarks. All elapsed time must be accounted for.

The question is often raised as to the length of the study. This depends on: (1) the importance of job, (2) how often it will be repeated, and (3) the elementary times available.

The practice of taking a ten or fifteen minute series of readings can, however, hardly be dignified by the term time study. What is wanted always is a typical performance, a cross-section of the day's work. Here again the nature of the process governs the length of the study. On a one hundred per cent hand operation a one or two hour study would be advisable. The observer must stay with a job long enough to be sure there are no unforeseen factors he has overlooked. The more highly repetitive the operation and the larger the group engaged, the more studies are needed to fix accurate standards.

Still another question regards the time of day to make a time study. No fixed rule can be laid down. We know the output curve rises from the first hour till the third or fourth and then drops back between ten-thirty in the morning and noon. It starts after the noon interval at about the eleven o'clock rate or less, gradually rises between two and three o'clock and then begins to drop. Where the elementary study is not checked against an overall study, it would be good policy to take one study between nine-thirty and ten-thirty and another between three and five o'clock.

Sizing Up the Workmen

The most important part of the observation covers the sizing up of the workmen. The observer must determine the kind of a demonstration he is getting. This is the most difficult part of the whole time study procedure. Any one with practice can take stop watch readings. Knowing what to do with them is the test of a good time study man.

There have been contributions made by engineers designed to supplement the observer's judgment. Messrs. Lowry, Maynard and Stegemerten have endeavored to rate the time study as to skill, effort, conditions and consistency, applying an algebraic correction factor. Under the Bedeaux method, the observer rates each element as to speed and effort. Unquestionably something of the sort is desirable and helpful. We should favor the rating of each element rather than correcting the total time, since it is well known that the highly skilled worker does not perform every element in a shorter time than the less proficient worker.

Meanwhile, pending the perfection of such a plan, if it is ever perfected, there seems no alternative except to rely on judgment. After a while, one should accumulate enough basic standards to use for comparison.

Relations of Observer, Foremen and Workmen

The time study man can make his job easier by conforming to a few simple policies. He is in a foreman's department as a visitor and as such owes the foreman the common courtesy of letting him know when he is to be there, keeping the foreman informed, talking over the job with him and having all directions issued through the foreman. He must use tact and discretion in his dealings with the workmen. During the process of taking the studies the time study man establishes contacts with the men which can help or hinder the negotiations to follow. By his fairness and reasonableness he can show the men that the management stands likewise for fairness and reasonableness, without which no time study program can ever succeed.

Discussion

Hugo Diemer.[15] What has been said on each of the three topics of the day's discussion, makes it clear that there is a distinct inter-relation between each of them, that is, the selection of workers, the number of workers, and methods of observation are matters that have a distinct bearing on each other. This is clearly indicated if we bear in mind certain fundamental considerations brought out by Mrs. Gilbreth in her book, "The Psychology of Management." The following abbreviated statement from the book brings out forcibly the objectives of time and motion study.[16]

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> *Time Study is Determining Standard Unit Times*:—Time study consists of timing the elements of the best method known, and, from these elementary unit times, synthesizing a standard time in which a standard man can do a certain piece of work in accordance with the finally accepted method.
>
> 1. The results are to be applied to all men equally.
> 2. All get an ample compensation for what they do.
> 3. Under them general welfare is considered. (When this is understood) the objections to such study will vanish.

Practically all experienced time study men will subscribe to the foregoing statement of the purposes of time study. It is particularly important that these purposes be borne in mind when we come to select the workers to be observed.

Where a number of such workers is available, a process of selection and elimination can be carried to a considerable extent through the medium of consultation of employment records and conferences with foremen. In this process of selection and elimination, it is not necessary to establish any numerical rating scales. A plus or minus sign opposite each of the following qualifications will be entirely sufficient. Important qualifications in the matter of selection are: (1) physical adaptation and dexterity, (2) intelligence, (3) speed, (4) accuracy, (5) temperament, (6) attitude.

Naturally that worker will be most desirable who rates plus in each of these six qualifications. Some of these qualifications, however, are far more important than others. For example, if a person rates plus in the first five, a minus rating after the item "attitude" should, nevertheless, practically eliminate him for time study observation. There is opportunity, however, for the observer to correct wrong attitudes by explanation and instruction. It is exceedingly important that the worker to be observed have a favorable attitude—one that is friendly and interested in progress. An attitude of distrust, fear or hostility may completely overshadow all of the other qualifications. Soldiering, inconsistent methods of operation, and the introduction of unnecessary elements make time study difficult if not impossible.

Next in importance is temperament. A high strung or nervous operator is undesirable, as is also one of phlegmatic temperament. It is exceedingly important to secure for observation an operator who is well balanced in temperament.

Next in importance comes accuracy. It is obvious that the worker who is inaccurate, given the proper tools and devices to insure accuracy, is a poor subject. Intelligence is also important as it means greater understanding and greater capacity for learning and co-ordinating.

Minus marks after the last three items in the list—accuracy, temperament and attitude—are more apt to eliminate the person under consideration than minus marks after the first three items; namely, physical adaptation and dexterity, intelligence and speed. Failure to consider these facts is very apt to result in building up erroneous instead of representative standards.

The "average experienced operator" is a desirable subject for time study. Experts are not common and speeding up an operator's rate of performance for the purpose of time study is not practicable. Therefore, the worker to be selected should be of average intelligence, speed, accuracy and dexterity, and normal as to temperament, attitude and physical adaptation. It is often difficult to find even these requirements in certain groups of employes.

Selecting the workers for observation, then, is important, and by proper consideration of this element of time study technique, much can be gained.

When only one operator is performing the task to be studied, the problem of selection disappears. If the subject does not meet the essential requirements of the average experienced operator he must be given instruction or another operator substituted. Human engineering, motion study, job analysis and training can here be applied to advantage in bringing workers up to average. It is especially important when short cycle repetitive operations are being studied that the proper operator be selected for observation and that information on the operation be complete.

When a number of operators are engaged in performing like operations the selection of operators to be studied presents a problem. Again a selection of average experienced operators is necessary. Overall times are not an index of an operator's proficiency, and for that reason a number of operators should be subjected to time study. Certain operators become expert in the execution of certain operation elements, which are motions of a short duration. By correctly analyzing an operation, and thereby determining the correct operation elements, the analytical phase of time study becomes a valuable device in determining both the base time and the correct or ideal method of performance.

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[16] Gilbreth, Lillian M., "The Psychology of Management," Sturgis & Walton Co., New York, pp. 105, 106.

A case may here be cited from the experience of Mr. Walter C. Hasselhorn, who has done extensive time study research at Wilson & Company, the Chicago packers. The example is the packing of sliced bacon in one pound cartons, a task requiring considerable skill and composed of many different motions.

When subjecting the group of ten packers to time study, six operators qualified as average experienced operators after their past individual production records had been examined and their method of operation and performance observed. The operation was exactly divided into its elements and a study consisting of approximately thirty minutes of watch readings was taken on each operator's performance. The cut-off points of each operation element were identical but in several cases a considerable difference in elemental times was noted. Individuals were following their own methods, and as a result, work was being turned out at varying rates of speed.

Investigation disclosed that certain operators were more dexterous in manipulating the forceps with which the bacon was handled; others displayed better skill in selecting and placing the meat before arrangement in the carton, and others showed greater proficiency in the arrangement of paper and layers. By determining the reasons for the lesser times, and instructing those operators who were less proficient in these elements, a means of obtaining the best performance from the entire group was developed. The importance of providing adequate training for industrial operations—especially those of a repetitive nature—is seldom realized without the stimulus of such a study.

Sometimes a practice of employing pace setters as subjects for time study is resorted to, but unless the regular operator performing the task is instructed so that he may duplicate the pace setter's performance, a means of obtaining maximum production is lost.

Having selected the operators to be studied by the means mentioned at the outset, an important section of the preliminary work yet remains. The time study engineer also has an important function as instructor.

Studying the operator of exceptional skill necessitates the adding of special proficiency allowances in order that the average operator may attain his performance. Thus opinion is injected into the calculation of the task standard. In observing the operator whose performance rate is below average, a correction is also necessary. Inconsistent operation times often result and a correction factor is necessary in order to adjust the time value to that of the average operator's rate. Correct employe performance is as essential as correct machine performance. As the feeds and speeds are corrected by the engineer to meet standard requirements the performance of the workmen must likewise be adjusted.

Having determined the average experienced operator's performance rate as equivalent to the basic wage, incentive should be provided to encourage the acquisition of individual skill and proficiency, an increase in effort and the elimination of waste time. This method results in the development of the expert workman. Speed, when it is possible to maintain it without producing cumulative fatigue, is a desirable factor, once the standard has been determined and incentive provided in compensation. The purpose of a study, however, should be to secure a consistent or normal performance rate, attainable over the entire day without producing any harmful effects upon the operators, equipment or product.

Correct engineering practice can create in the operating organization those influences that make for (1) physical adaptation—through job analysis and proper placement methods; (2) dexterity—through training and incentives; (3) proficiency—through the use of incentives; (4) accuracy—through training and the provision of proper tools and devices; (5) well balanced temperament—through the provision of proper surroundings, placement and industrial hygiene; (6) proper attitudes—through the maintenance of healthy industrial relations.

It is quite evident that time study cannot be considered as either a mechanical or mathematical process. Even the viewpoint that it leads to better methods engineering is not broad enough. It is an important link in the comprehensive and general scheme of industrial management, and those who direct its installation and operation must have this viewpoint.

Analysis of Data and Computation of Net Times

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TIME study is recognized today as necessary to equitable wage payments, the proper scheduling of material, an accurate measure of present plant capacity and the determination of future plant requirements. We now propose to use the studies as a means of establishing unit time laws. With the gradual increase in knowledge of the subject on the part of time study men, as well as of executives and workmen, there is an apparent desire to overcome those irregularities which appear with altogether too much regularity. The only answer is established laws. The problem is to discover and define these laws.

The majority of our time study men approach a job with the principal thought of setting a rate on that particular job. The operation is broken down into elements so as to eliminate all unnecessary work, but the elements are not chosen because of their similarity or relation to the particular class of work. For this reason it is difficult at a later time to compare this study with another on the same class of work. It is not possible to check the rate of speed of the elements of this study with others, and therefore the value of an element must be fixed by the judgment of the time study man.

When you place a series of studies on the same class of work together you find a wide variation in the values of similar elements—provided you are able to find similar elements. These studies may be all right for determining time values as a basis of wage payment because the law of averages may bring the total out about right. High time values are usually offset by an equal number of low ones. This is a questionable method, however, and it is necessary to find a way to set time values that will be recognized by all concerned as true values. These laws of true unit time values exist and are unconsciously used every day by the first class time study man with a good memory (not good judgment, as is popularly supposed) and the habit of breaking up jobs into the same common elements. It is our purpose to formulate the good memory of the best time study men into laws, similar to the laws of feeds and speeds, for the use of all concerned in the plant.

The majority of present studies are taken for what may be truly called temporary rates and are entirely unsuited for the establishment of standard time units. The elements are not specifically described or classified in such a way that a uniform rate of speed can be applied to the element when it appears later. Even the terms used in describing the element are changed from one study to the next. The whole study actually fails of the real purpose of a time study, which should be an accurate scientific description and measurement of the work being performed.

To illustrate the method we used in finding the laws which govern the output of machine work, insofar as the man is concerned, we shall describe the steps taken on the grinding operations on an automobile crankshaft. At the time, this crank (a six cylinder) was just nicely started in production in a shop which had never built anything but four cylinder cranks. All operations were on individual temporary piece work prices. The men were average workers in this line of work, and we had the fullest co-operation of the superintendent of the department. A general survey showed the work could be divided into five major classifications: (1) handling the crank, (2) manipulating the machine, (3) machine time, (4) gauging, and (5) necessary allowances.

We then broke the five major classifications up into common elements, separating the constant from the variable elements and arriving at our standard nomenclature.

A. Remove from conveyor and stand on end by machine. (C)

A. Remove from conveyor and land in machine. (C)

A. Pick up from floor and land in machine. (C)

B. Tighten tail stock (screw type) (V) per turns of handle.

B. Tighten tail stock (spring type) and clamp. (C)

B. Close hinge clamps 180 degrees (V) per clamp.

C. Tighten hinge clamp nuts with fingers (V) per thread times the number of nuts.

C. Tighten hinge clamp nuts with wrench (V) per sixty degree turn.

D. Start work spindle (shift lever). (C)

E. Move tools or work to contact (V) per inches per minute.

F. Engage feed. (C)

H. Machine time (power feed) (V) length of cut, divided by R.P.M. multiplied by feed, equals time of cut.

H. Machine time (hand feed) (V) per inch of travel or cubic inches of metal removed per minute.

I. Disengage feed. (Reverse of F)

J. Stop machine. (Reverse of D)

K. Release nuts with wrench. (Reverse of C)

L. Loosen nuts with fingers. (Reverse of C)

M. Open hinge clamps. (Reverse of C)

N. Release tail stock (screw type). (Reverse of B)

O. Release tail stock (screw type). (Reverse of B)

P. Remove piece to conveyor. (Reverse of A)

Q. Remove piece to floor. (Reverse of A)

After taking all of the studies we found many elements not in our original survey, but they came under the major classifications and had their own value.

In order to keep the machine running day in and day out allowances appeared necessary for (1) extra stock handling, (2) oiling machines, (3) cleaning out chips or mud from grinding wheels, (4) carrying water, (5) grinding and replacing tools, and (6) personal time.

We wish to stress the importance of a general survey before a first group of studies is made. This general survey is only a guide to what we want the studies to tell us. The studies will tell many more things than could be conceived in advance, but it is very necessary to have a predetermined and clearly defined course charted before attempting to sail.

In this case the constants were described in such a way that there was no danger of their overlapping the next elements. The variables had their range set and also the unit of measurement. We were then ready to go to the shop to take our studies, knowing just how to classify what we observed as we observed it. Our time study form was laid out to make twenty observations by continuous time, with the foreign elements at the top. The operators selected were considered the best. The elements were recorded in accordance with our standard nomenclature and the twenty observations made. At the conclusion the operator was rated according to the way in which he worked during the study. We took sixteen studies, sent them to the clerks to make the subtractions, and then analyzed the individual times of each element. The quality of the operator performing the work was first noted and constantly kept in mind as we studied each element. We first cut all times which were marked as not being true readings when the study was in process. With the obviously incorrect readings eliminated it was possible more closely to examine the balance of the readings.

The writer always puts a small x in the space above the time noted if the operator hesitates or if a foreign element actually enters without there being time enough to read and record it as a foreign element. The same is done if the reading is too small to be recognized as a true minimum time. Mr. Dwight V. Merrick tells us his general rule in considering what reading to keep and what to cut. He says a reading should be discarded if it is thirty per cent below or fifty per cent above the adjacent time. However, we found this true only on first class men working at their best.

The quality of the operators, because of the fact that men working on piece work have a tendency to hold back and not put forth their best efforts, has to be taken into consideration. The next thing to consider is the element itself. Is the nature of the element such as to lend itself to mechanical rhythm or not? Is there a chance for obstruction, beyond the operator's control, that would tend to produce a high deviation, or has there been a misreading? If the same time appears several times along the line it could hardly be a misreading. If it appears only once the times above and below should be observed to make sure the reading under question was not run into either the preceding or following elements. As a further check, some of the other studies should be looked over to see if the time appeared in them. In deciding whether or not to keep a reading the main thing to be determined is whether or not it is a true reading. Having decided this, every other element should be subjected to the same critical examination and comparison with other similar elements appearing in previous studies.

When the whole study had been checked, and all abnormally high readings and all low misreadings cut, the studies were returned to the clerks who summed each line, found the average time of each line, recorded the minimum time and computed the deviation factor by dividing the minimum time into the average time of each line. They also computed the average deviation of the study. When this average deviation had been obtained the calculated minimum was computed by dividing the average elemental time by the average deviation factor. This placed a value on each element of the study, using the same deviation and that of the whole study.

The studies then came back to the observer who first checked back the elements that had a very high deviation factor, in much the same manner as that already described. We found three studies which were not acceptable and they were retaken. The second studies proved satisfactory and the three were rechecked and discarded. We then had a set of studies from which it was easy to make standards.

To draw all of the studies together into one picture, it is possible to lay out a sheet sufficiently large so that all the elements under their proper classifications can be entered on horizontal lines. Vertical columns can then be drawn to record the calculated minimums, with a number at the top of each column to indicate the study from which it came. The lines can then be subjected to the same analysis that was given any of the studies or, as has been our practice, the lines can be averaged and the closest even number selected as standard. No further consideration need be given elements that are constant, but in the case of elements that are variable we have just one point established for a curve on the range of limits of the variations of the elements.

By very careful analysis of the time taken in each study, element by element, when the elements are properly classified and compared with ten or more studies on the same class of work, we can get a time value that represents an actual performance and remove all doubt as to whether it can be done again under similar conditions. We can eliminate the daily use of judgment by time study men in trying to guess the speed at which an operator is working. We set a time which is fair to management and to first class workmen and the value always remains the same.

When this practice is general, time study men will have an opportunity to study machines and men and to devise different or better ways of doing work. The time study men of the future will have less clerical work and more engineering problems to solve.

Computation of Allowances

By **NEELE E. STEARNS**
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THE subject to which I have been assigned, that of the computation of allowances, will be recognized by a great number in my audience as one of the most vexing problems encountered in modern time study practice.

The basis for the now highly developed elementary time study must be credited to Frederick W. Taylor's first distinctive contribution to the science of management. Mr. Taylor, endeavoring to determine "a fair day's work," observed that the chief reason why the employer failed to get it was that no one really understood the term. Industrial history, from what I am able to discern, records but two inconsequential attempts, prior to those made by Mr. Taylor, to determine maximum machine capacities or discover and register limits of human endurance when engaged in productive activity.

In his desire to set up tasks representative of "a fair day's work" Mr. Taylor separated his subject's task into its component elements, the timing of which became the basis for the preparation of the standard task time.

Up to this point time study practice seemed to present no serious problem; however, much remains to bridge the gap between measured productive effort over a short period of time and the result of cumulative productive effort for the entire working day. Several variable factors, usually occurring once or oftener in each operation, must be considered in determining the standard time for the given task. It is these variables, which make up the problem of the computation of allowances, which we are to discuss now.

In my opinion the use of the term allowance as a feature apart from the other constituent elements in the scientific development of the production schedule, tasks, piecework prices, etc., means very little. However, the term allowance gains significance when it becomes associated at installation with the particular plan of the commercial engineer or the individual policy of the specific plant; that is, when it is "tied in" with the other component features of the scheme.

Results in contented personnel and rock bottom production economies determine the satisfaction gained from the work of the commercial or resident engineer and reveal the accuracy of the scheme upon which the allowance calculation was based. Obviously, this is the commercial aspect of the development of time study practice.

The engineering or technical aspect, however, is a problem which presents various complications demanding constant attention in effecting valuable solutions. Untold quantities of material have been prepared by innumerable authorities on the loss of productive power in the worker because of fatigue, the value of rest periods to offset this evil, and the effect of incorrect lighting, unsanitary working conditions, etc., in slowing down production. It takes no stretch of the imagination to conclude that failure to minimize, and if possible eliminate, these defective conditions must materially affect the allowance factor. Therefore, I am presuming in my discussion that we are starting with fair normal working conditions.

These questions immediately arise. First, what are allowances as we understand them in time study work? What are their functions and of what value are they? In answer to the first question, let us consider an allowance as extra time which is added to the calculated base time to care for the several variable items which require an operator's time and which are not a regular part of any one task.

In proceeding let me stress the importance of striving for accuracy in this matter of allowance determination. Many engineers feel that the careful consideration of allowances is too technical and theoretical, or that the aim is too much toward the ideal, to be practical. However, the establishment of allowances, like the other exact phases of time study work, should be carried on with unerring determination toward accuracy. Clearly, a well calculated base time will be useless if the separate factors are not given due consideration. On the one hand, an incorrect resultant will lose for one the confidence and co-operation of the workers, while on the other, it will create an attitude of doubt on the part of the managerial staff as to the correctness of the incentive principle.

No job, regardless of its seeming ease of accomplishment, can be handled without at least considering the factors of personal care and fatigue; and almost all tasks, because of their various complexities, demand an investigation and solution of all the factors of allowance computation. Plainly, allowance reckoning is necessary in order to convert a theoretic base time into a workable standard in which the additional time is used by the operator as intended—to compensate for cumulative fatigue, personal care, profit and flexibility, as well as incidental irregularities.

To facilitate the collection of material related to time study methods now in use in industry, our Chicago Time Study Standardization Committee prepared and submitted to various industrial organizations, a questionnaire. One of the questions read, "What is your method of operation allowance calculation?" Answers to this question varied greatly, and I wish you would observe the total lack of time study engineering principles in some of the statements received.

To quote from the statistics gathered by our secretary, W. B. Lincoln, we found firms giving no allowance at all and others giving as high as a sixty-five per cent allowance. There were variations all the way between these limits.

The average figure considered sufficient for the total allowance to be given seems to be about twenty per cent. Eight firms made the statement that their allowances varied, no numerical values being assigned to them. To cap the climax, eight firms gave absolutely no allowance at all. I presume that these companies are super-efficient.

Further analysis of the returned questionnaires revealed 35.4 per cent of the companies replying allowed nothing for fatigue; sixty-seven per cent gave no consideration to delays of any kind; forty-seven per cent gave no personal allowance; 88.5 per cent ignored the profit factor; 92.5 per cent disregarded variations on the job; 10.1 per cent, as before mentioned, made no allowance of any kind.

These statistics, illustrating a widely varied practice in methods and reasons for allowance determination, reveal a neglect of a standard and scientific procedure for calculation. Of course, only indifferent results, of limited application, can be obtained under these circumstances.

To be basically correct, allowances should fulfill a dual purpose. First, when expressed as percentages of the standard time, they constitute factors to be used in compensating for certain delays encountered during the working day, and inherent in the operation performed, and for time consumed in foreign elements that are necessary when performed as supporting operations to the main elements of the job. Second, through the addition of time, they bring the accomplishment of the task within the range of the efforts of the average experienced employe in the allowed time, and provide further incentive for task achievement.

Allowances may be grouped under one of two classes according to the purpose they fulfill. I call the first incidental and the second standard allowances. Incidental allowances are readily measurable from the standpoint of time and, therefore, the experienced time study engineer encounters little difficulty in effecting their solution.

Mr. T. R. Hough, chairman of our Chicago Time Study Standardization Committee, in a lecture before the students of industrial engineering at Northwestern University, described the incidental allowance thus: "Incidental allowances are generally required and may be defined as time allowances which compensate the worker for an element of a task which occurs intermittently, incidentally, and which usually is of a nature thoroughly dissimilar in its motions to the one prescribed in the regular operation detail." These are many and varied, depending upon the industry. A few examples follow: stockup, machine care, tool care, truck handling, chip removal, gauging, inspection, coolant attention, permissible waiting, preparation time, etc.

Incidental allowances may be expressed in minutes consumed per day in the performance of one of these elements. Thus machine care may require fifteen minutes per eight hour day or three and one-eighth per cent of the total time. Stockup may be expressed in terms of time per piece, by dividing the stockup time by the number of pieces stocked up, and the percentage to be added to standard time thus determined.

The time study engineer must have good judgment in order to discern foreign elements of a major task, segregate them from the task and decide whether to treat them as incidental percentages of the base time or to set up a task standard to cover the otherwise incidental operation. In each shop there will be different factors to consider in making this decision.

The second of the two classes of allowances—the standard allowance—is calculated to compensate for fatigue, personal care, job flexibility and profit. It contains much of an empirical nature and is therefore subject to various interpretations and methods of determination.

It is obvious that the standard allowance percentage values, since they contain the element of incentive and profit, are materially affected in their synthetic structure by the policy the company wishes to pursue regarding the relation of the earned wage of the average first class workman to the basic wage rate for the occupation he is engaged in. It follows logically then that each of the component elements of the standard allowance must be analyzed, a value put upon it and its effect tested when applied to the actual performance of any group of operators.

In an effort to determine the influence to be accorded each factor in the standard allowance computation, let us analyze the separate factors in the order of their importance.

The Personal Allowance Factor

Though the items which come under this heading are limited in number, they are influential enough to warrant attention. In its baldest and most usual interpretation the term personal allowance covers only the worker's physical organ activities as influenced by his toil.

In my mind, this percentage factor should vary according to the nature of the job at hand. For example, when a man leaves work at the end of the day dripping with perspiration as a result of his work in a rubber mill room, it is good hygiene that he be permitted to bathe before leaving. The fact that thousands of workers still do otherwise does not lessen the hazard but only stresses the importance of our guarding our employes' health. Time spent in this way is not chargeable to fatigue, but has a direct bearing upon personal care. It should, therefore, not be a loss to the worker, but should be allowed, together with his other average physical requirements, as a condition of his task and added to the calculated standard time in the form of a scientifically determined constant percentage.

I cite the above as an example to point out the possible variations encountered in determining allowances. Most specialized tasks need only a body care factor, and in that event the needs of the normal person should be determined and considered a constant percentage of the standard allowance time.

The Fatigue Factor

In accounting for the fatigue factor it is always necessary to reckon with job conditions, surrounding conditions and the length of the operation at hand. During the last few years the question of fatigue has been widely discussed. Various formulas and theories have been advanced as to ways of measuring and counteracting industrial fatigue. These discussions have shown that fatigue is tied up with the formation of various chemical substances, the nature of which is still very indefinite and uncertain. A large percentage of fatigue measuring devices have been tried out only on laboratory experiments, and are not directly applicable to industrial fatigue allowance calculation.

It follows that the one best way of measuring industrial fatigue on the job is through a long time study. To illustrate, let us assume we are working on a product whose handling time is constant and that a correct basic standard of six one-hundredths of a minute has been established. Upon observing the operation over a long period of time we note that the operation base time rises from six to eight and nine one-hundredths of a minute. This loss, if reasonable, is the loss attributable to cumulative fatigue and must be compensated for in the allowance factor. Repeated computations can be made the source of fatigue allowance curves to cover short cycle operations on similar types of work.

Studies revealing tasks in which the conditions of the job are such that cumulative fatigue results require attention from two sources. First, as a temporary measure the men enduring the hardships should be compensated by a fatigue allowance factor for the losses incurred. Second, the fatigue producing conditions surrounding a given task should be scientifically studied to determine what corrective measures may be effected to reduce the evil and maintain the required flow of production. We are still very hazy as to the real nature of industrial fatigue, and more study on the subject is necessary.

The Profit Factor

Assuming the company policy to be a constant factor we must, when dealing with the profit factor, consider two elements, first, the proficiency attained by the worker, and second, the physical conditions surrounding the task that he is working on.

When an established standard is to be used as a means of determining incentive wages the use of a profit factor is advocated. This factor provides an incentive for the average workman to increase his proficiency and thereby his margin of gain. The time included in the determined base time, plus the several previously mentioned percentages or time allowance factors will, when properly installed, allow an employe to break even upon achievement of a given task. To provide an incentive for bettering the calculated task requirement, a profit factor, which will enable the worker to run over his occupational rating for better than standard production, should be incorporated into the standard.

The percentage of allowance to be attributed to the profit factor is usually out of the control of the time study engineer. Because of its concern with the problem of how much to pay for over standard production on distinctive jobs, it is a matter of house policy.

At present, judgment is the best method by which to determine the profit factor. The skill required to handle the job, as well as the conditions surrounding the task, provide concrete information upon which to calculate the profit factor for a certain type of work.

The Flexibility Factor

Minor unavoidable delays caused by inconsistencies in labor, material and operating conditions, necessitate the consideration of an allowance to cover this flexibility. The nature of work and the conditions surrounding the particular task are not always within the control of the worker. In the event of variations in materials, interruptions by foremen, production men, or engineers, or minor delays at various points on the product's route, delay allowances must be worked out to cover this loss in time.

The only correct way to determine the percentage to adopt is by an actual time study which will show up these variations. In ordinary practice it is often hard to detect the difference between fatigue and flexibility on short cycle operations. A means of checking worker's effort is through the test operator. However, from a personnel standpoint this is not always considered good practice, and is therefore not recommended as a method to be followed.

Assuming that the time study man has secured the right man for the job and that the conditions surrounding the job are as right as they can be, he should make a thorough analysis of the task to determine points at which time might be lost. He is then in a position to arrive at the correct allowance to make for the flexibility factor on that job.

In these notes I have tried to point out the factors which enter into allowance computation and, assuming that we were encountering a new problem, I have tried to illustrate the method of solution for each particular phase.

In summary, let us remember that allowances are divided into two classes—the incidental allowance and the standard allowance. Assuming that our scheme of allowance computation ties in with the balance of the industrial engineering procedure, we may state that incidental allowances are generally evaluated by the observer while on the job, while the standard allowance is determined by arbitration and experimentation, covering a more extended period.

In each case a percentage factor or time allowance is reckoned which, when added to our base synthetic time, produces a standard, the achievement of which is within the ability of the average experienced employe.

However, the problem of the correlation of these details remains unsolved. Obviously, allowance determination would be a difficult matter if such an involved procedure was necessary on each task. It is fortunate for us that we may resort to mathematics for, first, a graphical solution of the problem, and second, an empirical equation to conform to the pre-reckoned charting. Through the addition of an allowance from the curve thus derived a theoretic base time may be converted into a workable standard.

Each basic industry has its own problems to meet and accordingly a plan applicable in one situation will not suit another. Hence, in getting into a new field of work it is essential that the allowance factor be set up according to the needs of the industry. It is advisable, also, to follow a definite and scientific procedure, the determination of which will depend on the problem confronting the organization at the time.

The Production Study as a Check

By **L. W. HASKELL**
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OF ALL the great economists that I have read, I have yet to read one who has valued the importance of time. Any industrial engineer who devotes himself to the study of the utilization of time is looked upon by the average layman as a robber, because this layman thinks that the time study man is trying to get something for nothing. In reality the man that fully appreciates the importance of time and insists that his co-workers utilize their time, without waste, for productive purposes, is doing as much to elevate the standard of living, to make the luxuries of today the necessities of tomorrow, as any other person or persons following any line of endeavor.

Time was apportioned to man by the Deity. He shows no partiality. He allotted the same time equally to the hobo and to the capitalist. The only difference is that the former spends it and the latter invests it. I firmly believe that the big majority of us are capitalists, and I make this statement advisedly. Capital is but a word, though it means the accumulated difference between individual or group production and the corresponding consumption. For this reason any man who works, either with his head or with his hands, and saves a part of his income, whether it be for the purpose of buying a bond, a home, to educate his children or to have a little surplus for old age, is just as much a capitalist as a Morgan or a Rothschild. To me it is just as absurd for capital and labor to fight as it would be for the thumb and finger of the same hand to fail to co-operate.

It was undoubtedly a part of the great plan of things that man was created with an independent individuality and, with it, a varying degree of reasoning faculties. It seems that, through the economic conditions which are constantly becoming more complex, men are more dependent upon one another than ever before, and our mutual trust in each other is of paramount importance. The public at large demands that we have dependable men. In an effort to make themselves more dependable, men have unconsciously concentrated their studies and efforts on separate phases of this complex whole, and so have become specialists. This is the reason for specialists, and their ever increasing numbers, together with the intensity of the degree of specialization, show the trend of advance in civilization in this direction. Naturally we have our specialists in time study.

One of the largest manufacturers and producers of the present day does not admit having made a mistake. Errors in judgment are called by him increase in experience. Time study men are human. Humans make mistakes. Errors, entirely mistakes of the mind, occasionally creep into time study conclusions.

Time is money. A time study is made to determine the monitary value of an operation. It is an erroneous idea that time study is made only for a determination of a wage. The breadth of time study endeavor includes the collection of data, the bearing on plant load, quotas, fixed investments, cost estimation, fixing a wage, and many other factors.

In case a time study is made for determining a wage, discontent on the part of a workman may arise. With the possibilities of error, it is absolutely fitting and proper that every step be taken to prove to all concerned whether the workman or the study is fair.

It is about wages directly or indirectly that most serious industrial disputes arise. The individual is born with the instinct of self-preservation. We have interposed a device of wages between basic needs and their satisfactions. Wages, therefore, acquire the importance of both, and it must also be remembered they are the cushion between a state of anarchy and civilization.

We have societies of many kinds. We have our legislature with its endless debates. We have laws, so many in fact, that if we did not break some of them ourselves we would be a paralyzed nation. But where is there a rational study being made of wages, relative to work being done, by any other group than the time study engineers?

Time study in its present state has such a close relation to wages that it behooves men responsible for the studies to see that they are carefully and scientifically made. Fairness must be the keynote of the whole, if our work is to be a real benefit to mankind and to be perpetuated for future generations.

In my opinion, the best known means of checking a questionable time study is through a production study. In a well known automobile factory where an argument between the production division and the budget and rates division occurs, this is the instrument which is used to settle the dispute. They also use it in establishing a rate where the job is so full of variables that an equitable rate cannot be established through their regular time study procedure. The operations of straightening, metal finishing, cleaning, etc., are examples.

In illustration of the principles I have outlined, I wish to cite a case which came to my attention last week. Our time study engineer was checking some temporary rates he had set in the sheet metal hammer room. The results of these studies reduced the cost established through the temporary rates. The hammer men worked on their new prices for a few days and found that even the best of them could not make $1.50 per hour while working on the left hand fender. Therefore, we were asked to prove the equity of the reduction that had been made in the rate.

Checking our original study on the job, we found a note, transferred from part No. 37264, Front Fender Right Hand. In an automobile there are many parts which are identical except that they are right and left hand, and to conserve time and space studies are transferred from one to the other. Taking this study, we rechecked it for clerical errors and found everything all right as far as the study itself was concerned. As the very nature of the job makes it extremely difficult to get an accurate time, and as there was also dissension on the job, we decided to make a production study.

Another time study engineer was chosen to make this study, as he was neutral in the argument. He was not acquainted with the previous study, and therefore went on the job with an open mind.

After consultation with the foreman, one of the best hammermen was selected for the study. Using our standard time study form, the study began. First, by recording all the conditions as outlined on the form, breaking the operation down into its natural elements, and using a continuous running watch every move of the operator and all delays were recorded. (These delays are elements which do not recur in the performance of the operation.) This study was continued for a period of four hours and thirty minutes, three hours and thirty minutes being devoted to the study of the elements in this operation. In the course of this time, both right and left hand fenders had been run.

In analyzing this study and comparing it with the original study, we found the right hand fender checked very satisfactorily. Before a left hand fender would pass inspection, however, it was necessary to add another element to the study—hammer front crown section. This element had an actual time value of fifty-two and one-half hundredths of a minute.

Through this production study two glaring errors were brought out. First, the time study engineer had transferred a price from one part number to another on the erroneous assumption that both were identical, except that one was right hand and the other left. Second, an error had been made in the left hand fender die, causing the metal to wrinkle. This increased the cost of this fender approximately nine-tenths of a cent per fender.

Through the original elemental study, we were able to quickly ascertain the amount of work the price covered. Through the production study this was quickly checked; the price on the right hand fender remained the same, and a temporary price was set to cover the additional work on the left hand fender.

The superintendent of the pressed steel division was notified of the condition of this die and the resulting increase in the cost. This die was immediately ordered to the die room where it is now being corrected.

In conclusion, I would like to address a few words to the younger time study engineers. First, it is only common sense that we make accurate records, as they recall past problems and assist in analyzing those of the future. Second, management invests you with the responsibility of fairness and, third, the workman, who is closest to his bread and butter, generally has correct instincts as to evils, even if he flounders as to remedies. Through the use of the production study as a check, evils are readily segregated and eliminated. By the application of common sense, remedies can be applied that leave everyone in a frame of mind to enjoy the fruits of his labor.

Discussion

Harry Ford.[17] As Mr. Haskell in his talk has pointed out, "Time study men are human and humans make errors or mistakes." If these errors affect the earnings of individuals corrections are in order so that a fair adjustment may be made in their earnings.

In the case of the fender job used by Mr. Haskell as an illustration, the error could have been in the other direction; that is, a price could have been transferred to a part requiring less time. I cannot help but wonder if, in a case of this sort, the time study department would have heard any more about the matter.

As a check on standards determined by means of a time study I believe that in many cases a new time study will clear up controversies and settle arguments with regard to possible production. Time studies are as a rule cheaper to make than production studies, for they require less time. However, there is a real use and need for production studies. Their greatest value in my opinion is for use in determining allowances.

Allowances have almost as great an effect upon the "allowed time" or "standard time" as the total of the elemental times. The elemental times are more or less clear cut in the majority of time studies; that is, in our observations we are able to study closely and analyze the elements of an operation, on a number of pieces or through several cycles, without spending a great deal of time. We do not have this opportunity of close study and analysis on allowances unless our studies cover much more time.

It is because of this that I feel the greatest value of the production study lies in the opportunity it affords for determining and setting up standard allowances for certain classes of work and operations, and for determining the most economical machine tool. One machine may perform a certain element of an operation in less time than another machine, but the slower machine may do the work with less tool and machine trouble, and thereby actually produce more work during the average day. It is not the shortest time but the most effective time which is important, as Mrs. Gilbreth brought out last evening.

Where a discussion arises regarding the amount of allowance for tool trouble, there is no question but that a production study, over a period of a day, will lead to more accurate conclusions as to the amount of time required than time study. A production study will also reveal the effect of fatigue upon the operator. We all realize that during certain portions of the day a man produces more work. We have a fairly good idea as to the time of day at which the high and low production periods occur, but on many jobs we have little knowledge of the actual effect of fatigue on the production curve during the low periods.

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[17] Cadillac Motor Car Company, Detroit, Mich.

The production study also offers opportunity to determine general allowances caused by belt trouble, poor stock and miscellaneous items.

After listening to Mr. Haskell's paper I cannot help but wonder if we are using production studies as much as we should. I believe that the tendency is to guess at allowances rather than go to the trouble of determining by more or less scientific means what the actual allowances should be. I should like to hear some discussion of these points from the floor as it is only in knowing of the other fellow's experiences that we learn.

The Application of Time Study to Shop Operations[18]

By L. W. HASKELL
Dodge Brothers, Inc., Detroit, Mich.

THE relation of time study to industry is a field which research has not yet fully explored. In fact, it may be best to assume that to be the case with respect to the problem of time study in all its aspects. One must even question whether there has as yet been formulated a definition of time study acceptable to the scientific mind; therefore, I wish you to accept this paper as one applied to operations in our shop rather than to shop operations in general. I am not conceited enough to think that I know the rudiments of time study well enough to apply them to industry at large.

I do think, however, we have in our organization a common understanding of what is meant by the term time study. Otherwise our part in this conference would be a waste of time. Time study is a study of any task involving three fundamental considerations: with what implements is it performed; what is to be accomplished and how; how much time is required to perform the task expeditiously and economically. The last, the time required, is the all important thing to determine in any industrial enterprise, for it is the base measure of production, and the gauge of results.

Time study is essentially constructive in its function. It is not necessarily an economic arm, as profits may or may not be made without it, but because of its fairness to all concerned, it should not be overlooked in these days of complex problems. Its ultimate objective, that of arriving at an equitable time in which the work can be done, is reached only after each act and mechanism necessary to the completion of the work has been carefully analyzed, conditions improved, all unnecessary work eliminated and all acts essential to the job simplified as much as possible.

There have been many time study procedures developed in the past thirty-five years, and as far as I know they are all good that have the dual purpose of eliminating waste and increasing the material welfare of a people. One system may work better on certain lines of endeavor than another and, therefore, the choice of one procedure instead of another is largely influenced by the individual plant problems of quantity and quality of production as well as the nature of the product itself. The desirability of an accurate cost accounting system, a flexible production control system, or other managerial problems, often influence directly the choice of a system.

In our plant the functions are thoroughly departmentalized and each department has its particular responsibilities. The time study department comes directly under the factory manager. Its function first covered the issuing and maintaining of all changes on operation sheets. In this function we are closely related to the methods and equipment division, as they have direct supervision of planning all new work, the purchase of new equipment, the designing and making of new fixtures, and they also install and put these in order to produce at maximum efficiency. Operation sheets are really job specifications, or a series of statements of what should be accomplished in the course of the work. They are important to the time study department as the piece work tickets and the operation sheets, both of which are used extensively through the shop and also in factory accounting, must check.

The making of time studies today calls for a time study engineer. Here are a few of the qualifications I look for in picking such a man. I might add that our plant is of such magnitude and produces such a varied line that I do not attempt to pick men capable of going into every division to make time studies. If I need a man for the machine shop, I get one trained in that work; if I want one for the trim shop, I get one who has had a thorough training in that line, and so on. I try to maintain my force by taking men from our establishment rather than from the outside. Preferably I pick a man between twenty-five and thirty years of age, who has had a fair schooling and has demonstrated his skill in his particular line of work. He must be observing, have an analytical turn of mind, a keen sense of fairness, confidence in himself, and be willing to work. I mean work in the sense of effort, as continued effort is the price we must pay for all progress.

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[18] Papers presented at a joint meeting of the Taylor Society and the National Retail Dry Goods Association, Detroit, May 8, 1928.

When a man has these natural attributes it does not take long to train him to make good, intelligent studies. The longest part of his training is spent in learning the use of standard nomenclature. Without this you are lost when you wish to use your studies for establishing standards.

It is a difficult task to write a good job specification. If it is too short, it is of little help. If it is too long and detailed, it is confusing. It must describe every essential activity in a single clear-cut statement, contain every word needed to make the meaning unmistakable, and yet have no superfluous terms.

I should like to outline briefly the practice in our own shops in order to illustrate how time study is applied to shop operations.

We get a request from a certain department, say Department 20, to make a time study on Job No. 26241, Operation 4. This information is given to the time study engineer in that division. He first goes to the operation sheet, taking his time study sheet with him. He then records the following information: the part number, the operation number, the department number, the part and operation names, and also the time of day and the date. When he has this information he goes to the job and checks it. He next records the inspection requirements. Then his attention is directed to the machine by the order of arrangement on the time study sheet. He takes the machine name and number and notes its condition, the fixture number and its condition, gauges and their condition, belts and their condition. He notes the kind, hardness and tensile strength of the material. He gets this information from engineering drawings. He also notes the lubricant used, the revolutions per minute of the work or tool, and finds the surface feet on the controlling diameter. He checks the length and depth of cut and the feed; makes a sketch of the tools and of the part, showing the operation performed in red pencil, and then calculates the cutting time. After checking the above mentioned items, he should be acquainted with the job. Using our standard nomenclature, adopted for this type of machine wherever possible, he writes up the elements of the job. At this stage of the study constructive criticism is offered and the necessary changes are made. The decimal timer is then used. It is started at zero and runs continuously through the entire study, recording not only the elemental time, but all delays, necessary or otherwise. The number of cycles timed depends entirely on the job, but a sufficient number is made in all cases to get a true picture of the job.

The study is then handed to a clerk who makes the subtractions and computes the standard time by adding a percentage allowance taken from our fatigue charts. Labor as a whole is divided into several classes, each with its own particular base rate. At this point our standard time is converted into terms of money. The studies are then checked by a competent inspector. After receiving his approval they are sent to the typist, who types the piece work tickets, making five copies of each. The original ticket remains in the time study office, the second goes to the foreman, the third to the timekeeping office, the fourth to the factory accounting department, and last, but by no means least, the fifth goes to the count division.

I want to say at this point that we probably differ with ninety-nine per cent of the industries in that we no longer use standard time. We have converted standard time into money, and money is our unit of measurement.

The studies then go through the general office routine of keeping up an accurate car cost, by model, for each department. They are turned over to the standards department where new elemental readings are recorded and old ones checked. When this information is completed formulas and graphs are drawn off to be used in making future studies. Studies are then filed by part number and operation number.

In making up the payroll each individual is charged to an order number in accordance with the job he is doing. Therefore, when the entire payroll is assembled, and this is done at the close of every day, we have a payroll in terms of order numbers and money spent for each. Our order numbers cover direct labor in the foundry, in the machining division, in the paint division, in the assembly division, etc.; indirect labor, such as supervisory, clerical, machine setting, material handling and sweeping operations, lost time, overtime, piece work excesses, repairs to product, inspection, etc. The list might be extended indefinitely to cover every operation performed in the shop.

With direct labor segregated, and rates for it established by the best time study procedure we know, it becomes our unit of measure for all indirect labor activities that cannot be allocated accurately to their particular functions.

Using our direct labor departmental cost, we establish a cost for any given car schedule. This is converted into terms of men for direct labor. Again using our direct labor departmental cost, and an established ratio for indirect labor, we get our standard indirect labor cost. This is converted into terms of men for indirect labor. These figures must be calculated for each change in schedule and then sent to the production manager, who governs his shop accordingly. This does away with the irregular employment that is the result of haphazard planning, and is a real advantage to both management and workers.

Our daily attendance rolls are checked at irregular intervals to compare the actual men working with the men necessary for the car schedule. If the actual number is above the scheduled number, it is necessary to take steps to bring the force within our schedule requirements because, with more men than necessary in the department, the men receive less pay and, as you know, the employe's pay envelope is the very heart of all industrial relations. On it to a large extent depend the success and prosperity of American industry. If more men are in the department than necessary to produce the schedule and their earnings still remain the same, they are building up expensive inventories. In these days of rapid changes, that is not what most of us call good business. We therefore make a real effort to avoid such a situation.

Using our direct labor payroll as our unit of measure, we also plot a chart showing the ratio of scrap values and expense items to the direct labor payroll.

With all this information plotted on departmental graph charts, using direct labor as the base, the management is provided with a true measure of production, an intimate knowledge of conditions within the departments, and a simple guide to secure maximum results.

The Application of Time Study to Office Workers Both Clerical and Machine[19]

By WILLIAM H. LEFFINGWELL
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THE application of time study to office workers is the same as the application of time study to factory workers. There are differences, however, between office work and factory work. For example, in the factory you are working, as a rule, on something that you can see and feel. You can visualize the turning of a lathe, or a part of an automobile, or a garment, or some other piece of work. Although you may find an opportunity to improve the operation on it, still you know that there are certain operations that must be performed. That is not true of office work. You cannot tell by looking at the piece of paper upon which the clerk is working whether the work she is doing has any real value or not. It may be utterly unreasonable; it may be entirely worthless, and very often it is. Therefore, time study in the office requires that you be able to make not only time studies but also the requisite analysis to determine if the thing you are doing is worth doing.

Measurement of one sort or another is the beginning of all science, and as science progresses the measurements become more and more precise. To this universal rule scientific management in business is no exception. Time study in scientific management is a form of measurement which may be regarded as precise, although such terms as precision and accuracy are purely relative. In the days before mass production, the foot, inch and standard fractions of the inch were sufficiently precise linear measures for most purposes, but today, with modern methods of production and manufacture, the micrometer is an indispensable measuring device. The inch is now divided into thousandths, and in some cases even into finer divisions. So in former days the division of time into hours and minutes was fully satisfactory, and to a large extent still is; seconds are very rarely used except in scientific research. Now in the scientific development of business and manufacturing methods, more precise measurement of time also becomes necessary, and we have the time study, in which the minute is divided into hundredths. In some cases, work with the micro-motion camera necessitates its division into thousandths or even more minute proportions.

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[19] See footnote 18, p. 155.

Although time study is a most important element in the development of scientific management, it should always be borne in mind that it is by no means the beginning. As a matter of fact, it would be impossible in the average organization to develop a standard on any particular operation without previously standardizing other conditions which bear on the particular operation in question. It is this preliminary work—the prestandardization stage, as I term it—that should in every case be performed before time study is resorted to in the development of specific operation standards. In this prestandardization stage the crudest forms of measurement often become most important methods of analysis.

Thus, I have developed and extensively used one form of measurement by which I am enabled very quickly to determine the relative efficiency of any office organization. It is a method which has been applied very extensively to merchandising or manufacturing companies where most of the office work revolves around the order. The same plan can be applied to other types of organization where some other unit, not an order, is used. For example, in a department store the credit sales transaction can be used as a unit, as much of the clerical work revolves around it. In such concerns the volume of work is influenced either directly or indirectly by the volume of orders, as I mentioned before. The first step is to take the total number of persons working, either directly or indirectly, on the order. This will, for example, eliminate the clerks in the sales promotion and costs departments. The former are, of course, engaged in work which may result in future orders, while the activities of the latter are connected with production rather than with the handling of orders. The number of clerks working upon orders is multiplied by the number of minutes in the average working day, a calculation which gives the total number of clerical minutes. This figure is then divided by the average number of orders handled in one day. This average should be taken over a period of six months or more. The figure found by this division will be the clerical minutes per order. This process has been worked out in literally hundreds of offices. The average number of minutes per order varies from thirty to 1280. The latter figure was found in the office of one of the largest corporations in the country. This very crude form of measurement settles immediately the question of the general effectiveness of the office in handling orders.

The next step is to determine, with an equally crude form of measurement, the amount of time that is occupied on each of the operations in the routine. It is very seldom, indeed, that the total of the net time of these operations is more than one-half of the gross time. The difference is loss in efficiency due to faulty organization. If the same method is used to measure the effectiveness of departments, it can be very quickly determined which of them stands in most need of improvement.

This brings up another point. In these days we hear a lot about hand-to-mouth buying, and I should like to remind you that when you change one element, or one factor, of a problem you change the whole problem. As an illustration, and I think it a particularly appropriate illustration since we are meeting in Detroit, when the horseless carriage was invented they placed a motor in a carriage and everybody, even the inventor, thought that the only change that had been made was the omission of the horse. We know today, however, that the omission of the horse changed everything, even you and me. It changed our whole method of doing business, changed our customs and manners, and probably changed even our destiny. A lot of people have denounced hand-to-mouth buying as a terrible thing. The people who denounce it are the people who have to furnish the goods to those people who order in unequal quantities, and I admit there is a great deal to be said against the ridiculously small order.

I ran across a case the other day where fifty-five per cent of the orders of a company doing a business of $12,000 a year are less than $10 each, and thirty-five per cent of them are less than $5 each. This company is not handling wholesale orders as they think they are; they are handling less than retail orders. Mr. Everitt, President of Montgomery, Ward and Company, made the statement to me that their average retail order was $7.50, and yet this company is selling to retailers orders for $5. Inasmuch as it costs them $2 apiece to handle each one of these orders, you can understand how much profit they are making on fifty-five per cent of their orders.

Here is an example of a company operating on the old basis and thinking that it has only omitted the horse. They have an entirely new condition, however, and if they want to handle the situation they must have an entirely new order system. They must omit a lot of the unnecessary things they are doing at the present time.

Another equally crude measurement which I have often used to determine the flow of work through an organization is to attach to a group of ten orders a simple record upon which the worker on each operation in the routine notes the time he received the order and the time he finished with it. I have invariably found that this special batch of orders will travel through the routine much more quickly than will the average order, not so identified, which is, of course, to be expected. The results, however, are checked by initialing another batch of orders, without the knowledge of the employes through whose hands it passes, and sending it through the routine at the same time, carefully noting the time it started and the time the last operation was finished. The difference between these two will show whether or not the work flows smoothly.

Both of these methods appear crude as compared with the accuracy and precision of a time study, but they are nevertheless sufficiently accurate for the purpose and develop many important facts in the prestandardization period.

As another means of measurement I ask each section head to list the various operations regularly performed in his section, and to obtain an average time on each operation by recording the time on one hundred pieces. There is always a tendency on the part of the section head to overestimate this time, or at least to be exceptionally liberal in taking the records. Nevertheless, the information gained through this simple average time record is of extreme importance in improving the control of a department. This method also possesses a psychological advantage. Since it is performed by the section head it is not likely to be disputed by him.

This average time is termed production time, and the total number of pieces done in one hour on this average time is called a production unit, to distinguish it from the standard unit of work obtained by a scientific time study. A weekly report is then made to the department manager on which the total number of available minutes is obtained by multiplying the number of employes by the number of minutes they work. The total production units, expressed in minutes, is obtained by multiplying the production unit by the number of pieces handled. The number of these production units is then deducted from the total available time. The remainder, usually expressed in minutes, is converted into hours, which are termed lost hours. It is made very clear to the section head that the management desires a minimum of these lost hours, but that in office work it is never possible to eliminate them entirely.

I should like to explain that in the factory you can determine how many pieces you are going to put through each day, and as nearly as possible try to live up to your plan, but in office work the volume of the work is largely controlled by people on the outside. It is beyond your control. On Monday you have a big day; on Tuesday you have a light one, and so on.

The results of this measurement are frequently so startling that the section head immediately starts to improve the handling of the work so as to eliminate, as far as possible, the lost hours. If the initiative does not come from him, it is almost certain to come from the department manager, who does not like to have recorded, week after week, a large and unexplained number of lost hours in his department.

I mention these simpler forms of measurement to emphasize the importance of breaking down every management problem into its elements before beginning the precise measurement involved in time study. No intelligent person would begin the investigation of a social question in a large city by interviewing every inhabitant of that city in a door-to-door canvass. Such an investigation would require far more time and yield far less usable information than would an investigation which started out with a definition of its purpose and a thorough analysis of the problem, before any work was done. The city would then be divided into industrial or residential groups, and a typical sampling from each group obtained. No engineer would begin the development of scientific management by taking time studies of each individual operation.

Except for purposes of analysis, or the setting of standards, time study should never be used in an office. Its purpose is not to discover the entire time in which an operation can be performed, but the time required to perform each of the elements of an operation. So the attempt to find out "how long it takes the clerk to do it," whatever else it may be, is assuredly not a time study. Except for purposes of analysis the stop watch has no place in scientific management, and experiments made with it without the knowledge of the worker and his intelligent co-operation, are worthless. It is even worse than useless when used secretly, for when the worker discovers what is being done to him he will naturally resent the procedure, to the impairment of his good will and the office morale generally.

Recently I called at the office of one of my clients and the general manager had a very interesting story to tell me. He said that one of his girls had resigned, and when he asked for the reason, she said that she was not going to work where they took time studies of the length of time it took a girl to blow her nose. The next day one of the directors of the company called up and said, "I think you are carrying this efficiency business too far. I don't think you ought to make a time study every time a girl blows her nose." By this time the manager thought he ought to investigate and find out what it was all about.

There was a young man in the office who had been working under me. In his eagerness to learn something about simplification in management he had mentioned the subject of time study. I was not ready to do any time study work there, however, and had not gone into detail. He was very anxious to experiment and therefore bought a stop watch of his own. He was a little bit afraid to do the timing openly, and so pulled out the front drawer of his desk and put the watch in there. He could then time the girls without their knowing it, he supposed, and get his time study experience in this way.

It transpired that the girl he happened to be timing had a very bad cold. He had heard me say that in making these observations he should be very careful to get down everything he saw, so he noted the fact that the young lady had a cold and every time she blew her nose he noted, "Blew nose." One of the girls saw the record, and that is how the story started. No secret time studies should ever be made under any circumstances.

As before mentioned, the real purpose of a time study is to divide into its elemental times, or units, the time required to do a certain piece of work. At first the observer may have some difficulty in separating the motions, especially if they are being performed by a fast and skillful worker, but after some practice these difficulties will disappear.

Practically all office work will be found to consist of six elementary units:

1. *Preparatory Work.* In practically every operation there is a certain amount of preparatory work which differs in volume according to the operation. Thus, in running a stencil on a duplicating machine, the stencil must be put on the machine, the latter cleaned, inked and adjusted for use. If a letter is to be typewritten, the preparatory work may apply either to all the letters written within the day (such as cleaning the type or putting on a new ribbon), or to the mere setting of the machine for writing and the insertion of the paper.

2. *Sorting or Arranging Work.* This is an important element in all office operations.

3. *Searching and Finding.* This applies to every operation; in some it is a minor matter, in others, as in filing of all sorts, a very important one.

4. *Performing the Work.* This applies to the actual motions only, such as typing a letter, making an entry, or putting a letter into the files. Few examples of this element will of course be comparable.

5. *Removing Work* (or returning to position). This also applies to most office operations.

6. *Adjustment of Next Operation.*

These units may in many cases repeat themselves, and their performance is not necessarily in the sequence I have given.

A sufficient number of time studies of operations should be made to make possible the setting of standards. The longer the operation, it may be stated in general, the fewer the studies required, and vice versa. If the length of time consumed is five minutes, I generally make ten studies; if two minutes, fifteen studies; if one minute, thirty studies. For those of half a minute or less, sixty studies are required. On the whole it is better to have too many than too few, and perhaps it would be well for beginners to take twice as many as I have mentioned as my practice. A greater degree of accuracy will be assured.

A special form for recording these observations of elemental times should be provided, and as in all scientific investigations, everything that transpires is recorded. The sheet should be designed with this object in view. Many times in this work things are omitted which are afterwards found to have a distinct bearing on the problem, and if what is recorded cannot be used it can be readily dropped.

Great care should be taken in the selection of the person whose work is to be studied. The best clerk in any particular task should always be chosen. A time study should never be made of an inferior worker. The person to be studied should also be fully prepared for the experiment and should be convinced that it is no ordeal or trial. It should be made clear that its purpose is not to find out how fast *he* can perform the task, but rather that it is an impersonal scientific experiment in which he has been selected to take a part. The use of the stop watch should be explained to him as a necessity, not for timing him as an individual, but for discovering the elemental times of the various portions of the task. Very often you will come across people who are stop watch shy. I handle that type of person by having a little talk with him and explaining what we are trying to do and how the watch works. Then I usually leave the watch with him, suggesting that he try to figure out for himself how long the work takes, and go away. Of course, he very soon finds that he cannot time study himself, but his resistance is very easily overcome, and when I go back he is quite willing to have me proceed with the study. In short, his entire confidence should be gained before attempting the time study. The observer will then secure his willing and intelligent co-operation. No distrust or nervousness on his part will be likely to mar the experiment. As a matter of fact, the time lost in the most extensive explanation is not wasted. The more intelligent the person selected, the more readily will he comprehend what is desired and become interested in the work.

In making time studies, allowance must always be made for delays, and for this reason the sum of the times of the units of an operation cannot be considered as the total time to be allowed. In the actual work, delays are bound to occur; some avoidable, and others that cannot possibly be avoided.

The unavoidable delays are those which are inherent in the work or the worker. No clerk can possibly work at top speed every minute of the day, so fatigue is one of the factors for which an allowance must be made in the standard. Clerks will also have occasion to stop now and then, for other reasons than actual fatigue. Again, it is not to be expected that work will always flow smoothly without a hitch of any kind, not even in the well organized office. In setting standards these facts must always be taken into consideration and allowed for, as unforeseen and unavoidable.

It is true that no definite allowance can be made for fatigue, for it varies with the individual and has not as yet been measured. This allowance, though it cannot in the nature of the circumstances be definite, should be liberal In short, the standard maker will recognize it as an unknown quantity, to be estimated only.

The avoidable delays which occur are invariably to be attributed to some failure or shortcoming in the management. Machines that have not been carefully attended to may break down, or work may not be delivered in time. A small allowance should be made for these, but it is far better to have them recorded and steps taken to avoid them in the future.

In looking over some old records, I found several examples of time studies which I made as far back as 1915. They do not differ essentially from those of today except that they are made in seconds. The result obtained from them is much the same as that secured from present day studies. Here is the first, a study in filling and packing supply orders:

November 15, 1915.

Time Study

Operation: Filling and packing supply orders.

To check previous studies, which seemed to be too high, a study was made on twenty-four miscellaneous supply orders for packing and filling.

Item	*Seconds*
Time to fill	333
Average time per order	13.5
Time to pack	95
Total	441.5 seconds

Remarks: The filling can be done in shorter time if work is properly arranged. No attempt was made to speed up at all. The packing was very badly arranged. The packer fumbled, and lost many motions. It should be noted that from forty to sixty seconds of time were used for tying the string on a package.

The subject of the next study was posting cash sheets.

December 3, 1915.

Time Study (Miss Ableman)

Operation: Posting cash sheets—eleven items.

Item	*Seconds*	
1	23.4	
2	38.0	Filed wrong.
3	365.0	Payment all made. No supply card. Held for correspondence.
4	22.8	
5	22.0	
6	50.8	Initial different. Had to look on sheet five times.
7	20.4	
8	23.4	
9	24.0	
10	19.6	
11	18.6	

Total 628.0 seconds, or 10 minutes 28 seconds

Average—57 seconds
High—6 minutes 5 seconds
Low—18.6 seconds

The third study dealt with the simple task of addressing envelopes.

November 1, 1915.

Time Study (Miss Levinson)

Operation: Addressing envelopes from typewritten copy.
First test: Addressing from copy on sheet.

Item	*Seconds*
1	10
2	12
3	13
4	14
5	10
6	10
7	8
8	11
9	12
10	14

Total......114 seconds

Average per envelope—11.4 seconds
Second test: Addressing ten envelopes from cards—2 minutes.
Average per envelope—12 seconds.
Time on ten tests to insert envelopes—2.5 seconds.

The final example I give deals with various operations not counted as regular work. Similar operations occur on any clerical job.

November 2, 1915.

Time Study (Miss Fieldman)

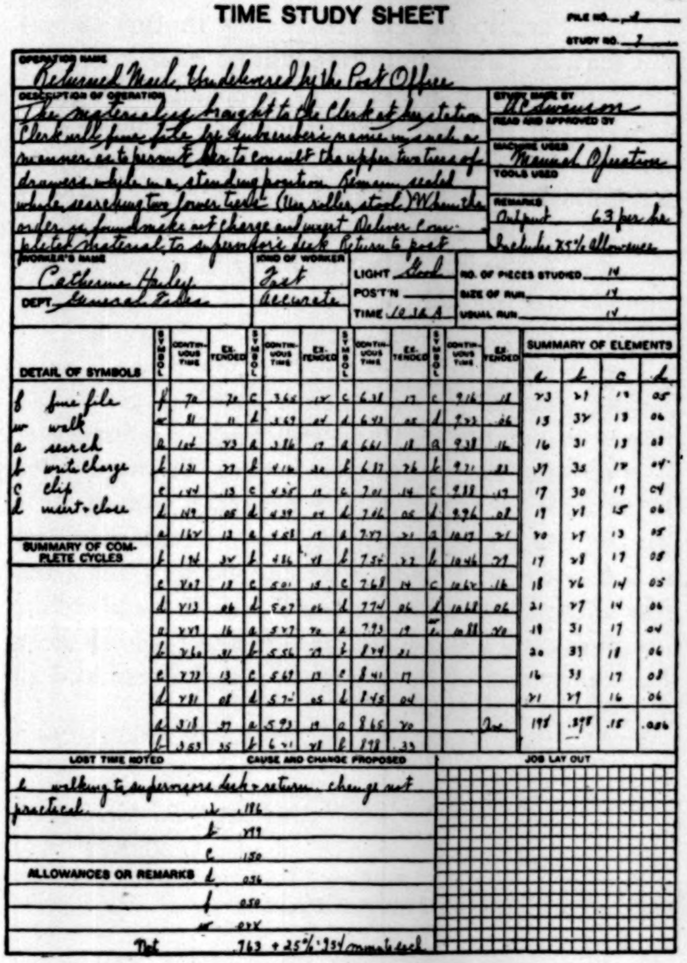
Time Study—one hour. Various operations not counted as regular work.

ASKING ROUTE MAN ABOUT ORDERS	REACHING FOR WORK	UNPINNING ORDER	TALKING TO MISS SASS	TALKING TO CHECKER	WAITING FOR WORK	GETTING ORDER BLANKS
20 sec.	3 sec.	6 sec.	18 sec.	10 sec.	228 sec.	85 sec.
20 sec.	6 sec.	12 sec.			150 sec.	
14 sec.	2 sec.				35 sec.	
20 sec.	5 sec.				15 sec.	
18 sec.					104 sec.	
4 sec.						
14 sec.						
110 sec.	16 sec.	18 sec.	18 sec.	10 sec.	532 sec.	85 sec.

Total of entire operation—789 seconds, or 13 minutes—*22%* of one hour—waste motion.

Since 1915 the systematization of time study work has proceeded rapidly. The sheet has been standardized so as to facilitate the work, with space left for all observations and remarks that may possibly have a bearing on the subject under study. The sheet shown here is a sample of a typical time study made in 1927, and taken from a paper which I read before the Third International Management Congress at Rome, Italy, in September of that year.

Before leaving the subject, I wish to point out that the person selected to do time study work should have more than the average intelligence, considerable power of observation and ability to suggest improvements. These qualifications are of vital importance. The person selected must then be thoroughly trained in the art of taking time studies. On operations with which he is unfamiliar it is not usually possible for the time study man to make observations for the elemental times and detect inefficiencies in the operation at the time the study is in progress. In general, it is preferable that the maker of the time study note the operation for a sufficient time to enable him to describe it thoroughly in writing, and point out what may appear to him to be waste motions, before he begins the actual study. Usually there is a great temptation to make merely an arbitrary division into elements, and then proceed to time these hasty and ill considered divisions. A study of this kind will not give information of much value, but if the procedure that I have sketched is followed



TIME STUDY SHEET

DATE: 5-10-27
FILE NO. 1
STUDY NO. 7

OPERATION NAME: Returned Mail, Undelivered by the Post Office

DESCRIPTION OF OPERATION: The material is brought to the Clerk at her station. Clerk will fine file by subscriber's name in such a manner as to permit her to consult the upper two tiers of drawers while in a standing position. Remain seated while searching two lower tiers (Use roller stool). When the order is found make out charge and insert. Deliver completed material to supervisor's desk. Return to post.

STUDY MADE BY: McSwanson
READ AND APPROVED BY:
MACHINE USED: Manual Operation
TOOLS USED:
REMARKS: Output 63 per hr. Include 25% Allowance

WORKER'S NAME: Catherine Haley
DEPT. General Sales
KIND OF WORKER: Fast, Accurate
LIGHT: Good
POS'T'N:
TIME: 10.16 A
NO. OF PIECES STUDIED: 14
SIZE OF RUN: 14
USUAL RUN: 14

DETAIL OF SYMBOLS
f fine file
w walk
a search
b write charge
c clip
d insert + close

SUMMARY OF COMPLETE CYCLES

LOST TIME NOTED / CAUSE AND CHANGE PROPOSED: d walking to supervisor's desk + return. change not practical.

ALLOWANCES OR REMARKS
a .196
b .299
c .150
d .056
f .050
w .027
Tot .763 + 25% = .954 minute each

JOB LAY OUT

Figure 12

the information gained from such a study can be of very great value to all concerned in working out better organization procedures.

In conclusion, and perhaps at the risk of some repetition, I wish to insist again that while time study is a form of precise measurement, and has great value in the development of scientific management, it should never be assumed to be the first step in that development, nor should it be undertaken until a sufficiently trained person has been secured to make the investigation. It should not be forgotten, either, that time study itself is in a process of constant development, and is as yet by no means perfect or universally applicable in any special form to all organizations engaged in business.

Frederick Winslow Taylor, a man who had a keen eye for future possibilities, seems to have had an idea that at some time in the future the application of time study might be incorporated in a handbook and become of universal use in production. He was evidently thinking of machine shop practice, however, when he stated at a meeting of the American Society of Mechanical Engineers, held in 1895 in this very city of Detroit, "Practically the greatest need felt in an establishment wishing to start a rate fixing department is the lack of data as to the proper rate of speed at which work should be done. There are hundreds of operations which are common to most large establishments, yet each concern studies the speed problem for itself, and days of labor are wasted in what should be settled once and for all, and recorded in a form which is available to all manufacturers.

"What is needed is a handbook on the speed with which work can be done, similar to the ordinary engineering handbooks. And the writer ventures to predict that such a book will before long be forthcoming. Such a book should describe the best methods of making, recording, tabulating and indexing time observations, since much time and effort are wasted by the adoption of inferior methods."

Thirty-three years have passed since this prediction was made, but it must be admitted that, while great progress has been made, its fulfillment is not yet reached anywhere completely, and most certainly not in office management. In my opinion it never will be completely fulfilled in the problems relating to office operations, for even in organizations engaged in similar businesses clerical methods differ, and sometimes very considerably. To divide the usual clerical work into the smallest possible units or elements by means of a time study is also not feasible, as the elements in such cases would be so minute as to render their timing of little value. You will remember that in this connection I have stated that we have no reason for believing time study will ever reach a state of absolute perfection. No form of human activity has as yet reached such a state, and there is no reason to suppose that more rapid strides will be made in this field than in many others.

For a long time then, at least, it will be necessary for each company to develop its own standards and elements, and I may say from my own experience, that there are few things that will pay more liberally for the effort expended toward organization improvement and simplification than the scientific time study.